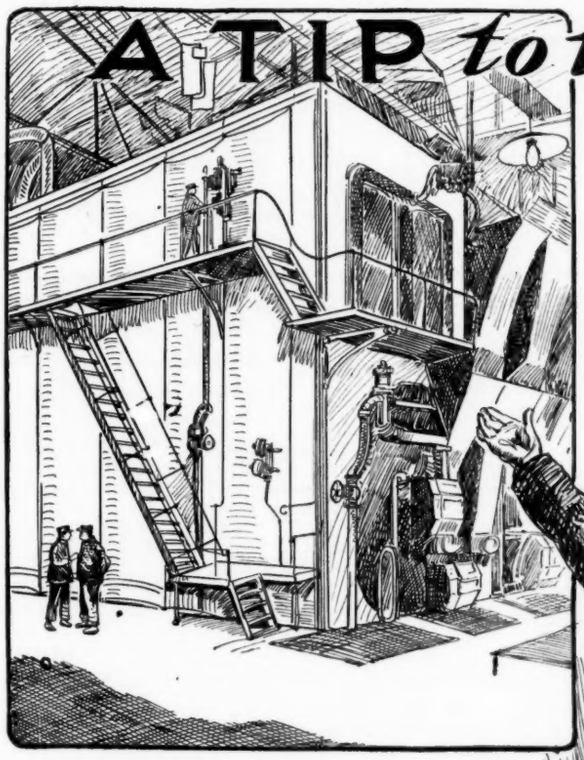
POWER

Vol. 45 NEW YORK JUNE 12, 1917 No. 24

A TIP to the "OLD MAN"

By H. C. Gibson

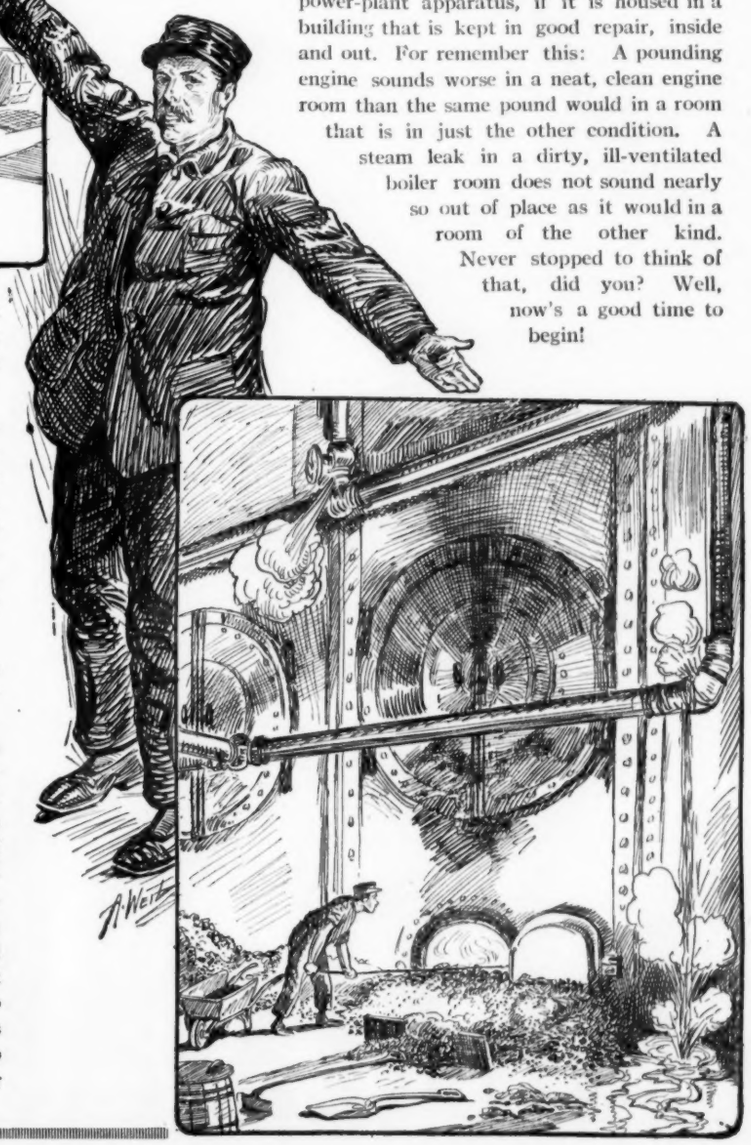


IS IT YOUR DESIRE to have the power-plant equipment in your establishment in the best possible condition, both as to mechanical efficiency and neat, shipshape appearance?

Maybe you are one who, when you first took the reins in hand, spotted several pieces of apparatus which you thought would make a better showing if they were gone over with waste and elbow grease. Maybe you issued a bulletin urging the force to greater endeavor along that line. But it is just possible that if you did, your hopes of seeing an immediate change of any consequence were not fully realized.

Now, you had a right to expect that your desires in regard to this matter would be carried out. Maybe they were, to the best of the ability of the force. Maybe you put more load on your employees than they could carry in addition to what they had before. The most essential thing in a plant, after all, is to keep the wheels turning. After that, if there is any time left, your men will probably meet you half way in keeping the equipment in first-class appearance as well as running order. But here is something which maybe you did not consider. Did you ever stop to think that, no matter how "spick and span" the engine-room and boiler-room equipment is maintained, there is not much incentive to keep it in this condition unless the surroundings are in harmony? To come to the point: Do you realize that where the engine and boiler rooms themselves — I mean the floors and the walls and ceilings—are kept in a neat, attractive-to-the-eye condition, there is a psychological force present which will react on your men and tend to bring out their best efforts in their work of maintaining the apparatus in their charge? The psychological incentive to keep the engine and boiler-room equipment in tiptop shape is in direct ratio to the appearance of the building in which such equipment is located.

You will find that your men will be quicker to look after the little knocks and leaks which are always showing up around power-plant apparatus, if it is housed in a building that is kept in good repair, inside and out. For remember this: A pounding engine sounds worse in a neat, clean engine room than the same pound would in a room that is in just the other condition. A steam leak in a dirty, ill-ventilated boiler room does not sound nearly so out of place as it would in a room of the other kind. Never stopped to think of that, did you? Well, now's a good time to begin!



Economizer Explosion Explained

SYNOPSIS—Economizer explosion causes approximately $35,000 property damage. Equipment had been in service but nine months. Analysis of the accident shows that the outlet valve on No. 2 economizer was either closed or nearly closed at the time of the explosion. It appears that steam filling the top headers raised their temperature above that of the tubes, causing the headers to expand, and one or more were forced off the tubes, causing the initial rupture.

On the morning of Mar. 30, at about 3 o'clock, an economizer at the plant of the St. Lawrence Pulp and Lumber Corporation exploded with great violence. This plant is on the Gaspe peninsula at Chandler, Que., Canada. Owing to fortunate circumstances, no loss of life or injury to persons resulted from the accident, although three men were in a room immediately below the economizer at the time it exploded. The economizer equipment consisted of two economizers of 40 tubes each, the tubes being 10 ft. long. They were placed on each side of a radial-brick stack, as shown in outline in Fig. 1, the No. 2 unit being the one involved.

The boiler room and power house were of the most modern steel and concrete construction. The violence of the explosion may be judged from the fact that about 5000 sq. ft. of 4-in. concrete roof was blown off bodily, and about half the steel roof trusses, columns and roof members serving to support this area were carried away. Additional roofing to the extent of about 3000 sq. ft was so badly damaged as to require renewal. A portion of a roof truss and supporting column may be seen in the foreground of Fig. 2, at a point about 150 ft. away from its original position, where it landed at the time of the accident. The side walls of the building were of 10 in. concrete with pilasters 2 ft. square. A section of this wall about 50 ft. long at the rear of the exploded economizer was blown down, as illustrated in Fig. 3.

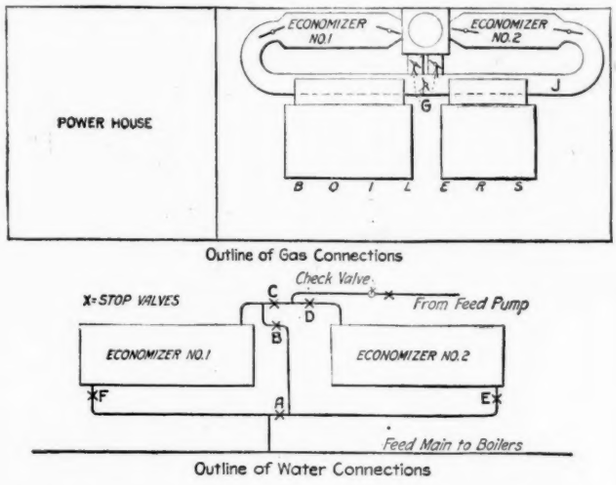


FIG. 1. DIAGRAM OF GAS AND WATER CONNECTIONS OF ECONOMIZERS

Headers, tubes and roof members were scattered in all directions for a radius of about 500 ft. Parts of the headers, tubes, etc., may be seen in Fig. 4, which shows a portion of the roof over the coal conveyor, this roof being about 10 ft. above the level of the main roof of the boiler house. Not a section of the economizer was

FIGS. 2 TO 5. VIEWS OF THE RESULT OF AN ECONOMIZER EXPLOSION AT CHANDLER, CAN.
Fig. 2—General view of wrecked building. Fig. 3—Opening blown in rear wall of the boiler house. Fig. 4—Roof over the coal conveyor on boiler house. Fig. 5—Looking down in opening blown in the roof

left intact, the tubes being either pulled out of or broken off in the headers, this being true of both the top and bottom ones. Practically all the headers were broken in two or more pieces similar to those illustrated in Fig. 4. A view looking down through the opening blown in the roof is shown in Fig. 5.

At the time of the accident both economizers were in service. All the dampers, marked *G* in Fig 1, were closed, so that the gases from a portion of the boilers were conducted through the No. 1 economizer and those from the balance through the No. 2. Water valves *A*, *C* and *D*, Fig. 1, were open and the valve *B* closed, so that the economizers were working in parallel as far as the water connections were concerned. Outlet valve *E*, from the No. 2 economizer, was carried away by the force of the explosion, but was found later, and it had either been closed or nearly so at the time of the accident.

Although, as is commonly the case in this class of accidents, the explosion of gas was given as the cause by the experts who investigated the explosion, there was very little likelihood that such was the case. The section of the flue marked *J*, Fig. 1, which was on the same level with the economizer and between it and the boilers, was crushed up against the rear of the boilers and was not carried away by the force of the explosion. In fact, the cushioning effect of this section of the flue was undoubtedly the factor that prevented the accident to the economizer from producing an explosion of the boilers. If an explosion of gas had been the cause of the accident, it is more than likely that this section of the flue would have been blown apart, since it must have contained as much or more gas, and of approximately the same composition as that in the economizer and under possibly more favorable conditions to produce damage by being exploded.

It appears that what really happened was that the outlet valve *E*, Fig. 1, was closed or nearly so and that, owing to this stopping the circulation of the feed water through the economizer, it began to steam. As soon as steam filled the top headers, their temperature was raised above that of the tubes attached to them, causing the headers to expand, and the ordinary working pressure of about 190 lb. forced one or more of the headers off the tubes, starting the general wreck of the economizer.

Another fact that tends to confirm the foregoing explanation as to how the accident occurred, was that a recording thermometer, which registered the temperature of the water leaving the economizers, located at a point in the pipe leading from the economizer main to the boiler-feed main, indicated a temperature of about 180 deg. just before the accident. This low temperature confirms the probability that No. 1 economizer was passing all the feed water used, as was evident from the condition of valve *E* as found after the accident. Although only one of the two safety valves with which the exploded economizer was equipped could be found after the explosion, and this one was in three pieces, it was evident from the condition of the parts that the valve was in good working order at the time of the accident and not set for an excessive pressure. The economizers in the plant were new, having been in service only nine months. The property damage was about $35,000.

Review of Condenser-Tube Corrosion

By Charles H. Bromley

SYNOPSIS—Tells of the important results of Bengough's most recent research. The circulating water is from the sea at Brighton, England. Air entrapped in grooves in tubes usually leads to corrosion. Tests are to be conducted on oxide-free metals. Muntz metal but lightly affected by local electrolytic action. Good results are expected from copper-aluminum alloy.

In 1913 Guy C. Bengough and Richard M. Jones reported results of their researches into the corrosion of condenser tubes, as made for the Corrosion Committee of the Institute of Metals (England). Mr. Bengough, after the committee originally appointed by the Institute of Metals to investigate the corrosion of condenser tubes had been reconstituted so as to include representatives of the Admiralty and the Board of Trade, has been selected to give his whole time to the work of investigating the subject. The British government has appropriated money to help carry on the work. The research is being conducted in the large electric plant at Brighton, and laboratory investigations are being made in the Royal School of Mines, under the direction of Captain Bengough. Those acquainted with the complexity of the subject will commend this change.

As Bengough's work is perhaps the most authoritative and the most complete, it may be well to go a little further than to merely review his more recent work as reported this year and include some of the chief results obtained by him during the last several years. Inasmuch as the work of John P. Sparrow, chief engineer, New York Edison Co., dealt with the microstructure of condenser tubes as such structure influenced the life of the tube, it also is pertinent to give the chief features of Mr. Sparrow's experiments, which, however, have already been reported in *Power* for Oct. 14, 1913.

To refer to Bengough's recent report to the Institute of Metals: The cooling water at Brighton is obtained from the sea, and so far as we are able to determine, contains little or no sewage and acid, as is peculiar to waters available for condenser purposes in most of the large cities. Bengough shows that "spills" which originate in blow-holes against the sand core of the castings from which the tubes are made, usually lead to corrosion. When a tube containing a spill is drawn, the spill, by being drawn out, causes a long groove in the tube into which air may collect, and in the presence of sea water corrosion results.

It will be interesting to get the results on corrosion tests of oxide-free metals, as this will determine whether the presence of oxide in the tubes promotes corrosion.

Brunner-Mond zinc, melted in an atmosphere of hydrogen, the molten metals not being cast but allowed to set in the crucible and cool therein, the gases occluded should not be trapped when the metals solidified. These tubes are being prepared by the Broughton Copper Co., and Captain Bengough is soon to experiment with tubes made of this material.

Tests with Muntz metal, which contains 2 per cent. of lead, have shown that it is but lightly affected by local electrolytic corrosion. The lead forms a basic salt which seems to spread over the surface of the tube, protecting it from further corrosive action. An alloy of 10 per cent. nickel and 90 per cent. copper has proved quite immune to attacks in the laboratory. It would be interesting to know of what metal the condenser shell and tube sheets were made in which the nickel tubes were placed when under investigation. A copper-aluminum alloy has been under test by Bengough, and specimens have developed small pinholes which deepen rapidly. This alloy consists of 92.2 per cent. copper and 7.8 per cent. aluminum.

Sparrow's Experiments with Aluminum Bronze

It will be remembered that John P. Sparrow, chief engineer, New York Edison Co., made, as chairman of the Turbine Committee of the Association of Edison Companies, interesting tests on the behavior of condenser tubes, among which were some of the aluminum bronze, or the 92 per cent. copper, 8 per cent. aluminum composition. A lot of these tubes had been in service 4½ years and showed no signs of deterioration. On the other hand, a second lot of the same mixture, under similar service conditions, failed completely in four months, while a third lot, in service at the time the tests were reported, showed every sign of giving as long a life as the tubes in the first lot. Mr. Sparrow's results dealt largely with the microstructure of the various metals of which condenser tubes are made. The experiments showed that there are many reasons to believe that if these aluminum bronze tubes are given a slow anneal at a temperature of about 750 deg. F., and are hard-drawn, a close metal of uniform grade will result, giving a tube whose life will be much longer than those of the universally favored admiralty composition. Unfortunately, the mill treatment of these tubes is so irregular as to give very erratic results in their behavior in service. Workmen have had many years' experience in the mill treatment of tubes of admiralty composition, and one is inclined to believe that if commercial conditions would warrant, these men would eventually become so skilled in the production of these aluminum bronze tubes that each lot of tubes would be appreciably more dependable than is now the case.

As investigations of the subject go on, the belief becomes more general that corrosion is not due to stray electrolytic currents, but rather to galvanic action between the constituents of the metal itself. We are inclined to the belief that corrosion of condenser tubes is influenced very appreciably by the internal strain in a metal composing the tube. Sparrow, for example, found, and it is known quite generally to those in the copper-tube industry, that condenser tubes split while lying in the stockroom where they are not handled or subject to any influence other than internal stresses.

In experiments made by Captain Bengough, reported before the Institute of Metals and abstracted in the December 2 and 9 issues of *Power*, 1913, it was pointed out that in nearly every case the deterioration was due to dezincification, resulting in a spongy and pitted tube. It was further found impossible to correlate the failure of the tubes with the electric machines or lines of the electric-lighting installations in the plants investigated.

A detailed examination of the scale attached to the tubes was made. In normal cases it could be regarded as made up of several layers of different compositions (the water used was sea water). The top layer consisted principally of ferric-oxide, carbonate and chloride of calcium and magnesium, calcium sulphate and sand; the next layer consisted of basic chloride and carbonates of copper and zinc, and was greenish in color. The layer next to the tube was brown or black and consisted largely of cuprous and cupric oxide. In most cases the lower layer of scale strongly adhered to the tube.

No Carbon on Corroded Tubes

In all cases in which the tube had suffered dezincification the greenish blue layer was replaced to a greater or less extent by a white flocculent salt which was found to be a basic chloride of zinc. A careful search was made among the deposits in badly corroded tubes for carbon particles, but in no case were such particles found.

In a former paper Bengough protested against the practice of dividing a condenser into two nests, claiming that that was an aid to corrosion. As the water passes through the lower nest, it becomes heated and consequently the top nest is supplied with water that is already warm and will become still more highly heated. From the corrosion point of view it would be preferable to introduce a separate water inlet and outlet to each nest of tubes or discontinue the practice of building them in nests.

The speed of water through the condensers in the mercantile marine varies between 240 and 360 ft. per min.—the average is about 290 ft. per min. The speed of the water used in the experimental plant was 275 ft. per min. The faster the speed of the water in the condenser the lower the temperature, other things being equal, and the less the liability of choking the tubes. In the author's (Bengough's) opinion the speed should be kept up at the highest figure mentioned, and it might be worth while to try still higher speeds if the tubes frequently choke. It is generally recognized that galvanic currents due to deposits of active material inside the tubes are responsible for a great deal of condenser-tube corrosion. That such corrosion is likely due to iron oxide being carried into the tubes seems to be borne out by the observations reported from many different sources. For example, Bates in the "General Electric Review" of a few years ago, reported that 96 per cent. of the tubes examined by him during some research work were pitted in the lower half where internal deposits would settle.

Bengough on Effect of Carbon

Mr. Bates thinks that along with oxide of iron carbon also was deposited in the tubes and gave rise to injurious electrolytic action. The researches of Bengough seem to show definitely that deposits of carbon do not influence corrosion. In his 1913 report, already referred to, Bengough states that the tests bring out the fact that the locality in which the dezincification occurs is not determined by the electrochemical action of the carbon or any other foreign particles settling on the tubes, but is the result of a chemical action which becomes

the more pronounced as the temperature of the tube is raised from the ordinary temperature to 122 deg. F., or thereabouts. Tubes of admiralty composition (70 per cent. copper, 29 per cent. zinc, 1 per cent. tin) are less influenced by the temperature condition than tubes of other compositions.

It is quite likely that corrosion due to fine particles lodging in the tubes is less severe in the more modern condensers than it is in those installed some years ago. This is due to the marked increase in the velocity of the circulating water through the tubes. Velocities of 200 to 360 ft. per min. were about as high as circulating-water velocities were carried; but in an effort to get a smaller number of square feet of tube surface to transmit a given amount of heat in a unit of time, water velocities were increased to as high as 600 ft. per min., with 480 ft. per min. as a fair average for present-day condensers. With such high velocities there is less chance for foreign substances to remain in the tubes.

Reports of researches carried on by different engineers seem to indicate that dezincification is a chemical process and that the deterioration of the tube after dezincification occurs or has been completed, leaving the tube a spongy mass, is purely mechanical, the tube being, in engineering parlance, rotten.

Influence of Oxide of Iron

Relative to the influence of oxide of iron on the corrosion of tubes, Bates, an Australian engineer, reported that serious corrosion of condenser tubes at the Sydney Tramways power house had been checked by painting the water boxes, which were of cast iron, with an anti-corrosive paint. Researches seem to show further that the rapidity of dezincification increases with an increase in the proportion of zinc in the tubes. This in a measure seems contrary to general belief and contrary to what one would naturally look for. One would expect that the larger the mass of metal exposed to corrosion the less would be the rate of corrosion, that is, the less absolute weight of metal would be destroyed in a given time.

Bengough showed that only one sample out of 20 tubes could remain in sea water—and this sea water was quite free from vegetable and acid impurities—at 104 deg. F. for a month without corroding. As far back as 1905 the late B. F. Isherwood, chief engineer of the U. S. Navy, in some notes on a paper by Uthemann, of the German navy, on a process for preventing the corrosion of copper and brass by sea water, said: "As regards the temperature at which the corrosion takes place, the higher the temperature of the metal the more rapid is the rate of corrosion. This result is doubtless due to the fact that the density of the metal decreases as the temperature increases, the molecules being kept at a greater distance apart with higher than with lower temperatures, whereby the force of the intermolecular, or cohesion, attraction of the metal is some ratio to its increase of temperature, and its resistance to chemical combination with other substances is correspondingly lessened."[1]

It would appear from the experiments of Bengough reported four years ago that it is not strictly true that the rate of corrosion increases with a rise in temperature. In experiments on tubes of 70:30 and 70:29:1 alloys the former showed clear signs of dezincification after seven days' immersion in water at 122 deg. F., while the latter, or the admiralty composition, showed no signs of corrosion or dezincification at the end of six weeks. On the other hand in three weeks this alloy (admiralty) showed signs of corrosion in water kept at 104 deg. This would indicate that there is only a limited range of temperature at which dezincification takes place, at least in tubes of admiralty composition.

[1] "Journal of the American Society of Naval Engineers," August, 1907.

High Water Velocity Beneficial

Although it was mentioned in a preceding paragraph that the rate of corrosion due to impurities or foreign substances deposited in condenser tubes would likely be less in the more modern condensers, owing to the increased velocity of the circulating water through the tubes, it must be remembered that with a high velocity of water the oxides and salts formed do not have an opportunity to coat the tubes as they would when the water velocity is considerably slower. It is therefore probable that with the high velocities of the circulating water the tubes are more thoroughly washed and have a larger portion of the raw metal exposed to the corroding action of the water.

These high velocities of water through the tubes have a tendency to keep down the temperature of the tubes, even though the amount of steam condensed per unit area of tube surface may be very high, and as corrosion is so greatly influenced by temperature, this good effect of high water velocities becomes important. In this respect, when a condenser tube becomes choked with scale, the temperature will rise considerably above normal or above what it would if it were clean, therefore corrosion is likely to go on at a higher rate even under the scale. This seems to have been observed in the experiments by Bengough, where he found that tubes in the bottom, or cooler part, of the condenser, which were coated with scale, did not corrode nearly as rapidly as those in the upper part of the condenser, which were also choked but which were subjected to the temperature of the incoming steam.

Why Not More Lead in Tubes?

The water in Boston Harbor is not nearly so impure as that in New York Harbor or in the East River. In one large plant at Boston condenser tubes containing 12 per cent. lead have been in continuous service for 12 years and show no signs of deterioration other than what would be expected from general corrosion. There is no selective corrosion taking place in these tubes. In none of the experiments by Bengough or Sparrow, or in fact any other investigator, have there been tubes that contained over 2 per cent. lead, so that there appears to be little information other than in the instance just cited of the behavior of tubes containing from 2 to 10 or 12 per cent. lead. Lead is highly resistant to corrosion, and it seems that it would, if supplied in a reasonably large amount, prevent internal strains being set up in a tube, and should therefore relieve all splitting or other troubles due to internal stresses.

Although the recommendations of Sparrow were once given in *Power* (Oct. 14, 1913), it seems that circumstances warrant their being mentioned here. It was stated that while it is impossible to draw definite conclusions from the many experiments and investigations,

it seems reasonable to conclude that the user may protect himself by requiring the manufacturer to furnish, first, mechanically perfect tubes—that is, free from slivers, blisters or spills; secondly, tubes of uniform hardness, as shown from tests of samples selected at random throughout the lot, the test to be a deflection between one-inch square blocks, the tubes weighted to secure deflection of 0.005 in. (for the admiralty composition, 70:29:1 mixture, this weighting should be from 400 to 500 lb. for a 1-in. outside-diameter tube No. 18 B.w.g.); thirdly, tubes of uniform grain size. This relates to cross-section, the fine grain to be secured by annealing slightly at a temperature of 750 deg. F. A finely finished tube is indicative of final hard drawing, which produces a very ununiform structure and is therefore undesirable.

It is important that the reader be advised that in the foregoing experiments salt water or sea water is the water to which the tubes were subjected in all cases. For fresh water Muntz metal seems to be the most desirable, considering price and results. These tubes are used in nearly all of the larger American power houses where the circulating water is fresh. Some years ago A. E. White conducted an investigation for the Edison Electric Illuminating Co. of Detroit, and for those water conditions Muntz metal proved best during the research work. Experience with this metal since then has shown that the conclusion is well founded. For fresh and unpolluted water Mr. White believes that tubes of 70 per cent. copper and 30 per cent. zinc will give best results, while for salt or polluted water admiralty mixture is best. This of course is borne out by general experience.

Reversal of Exciter Polarity

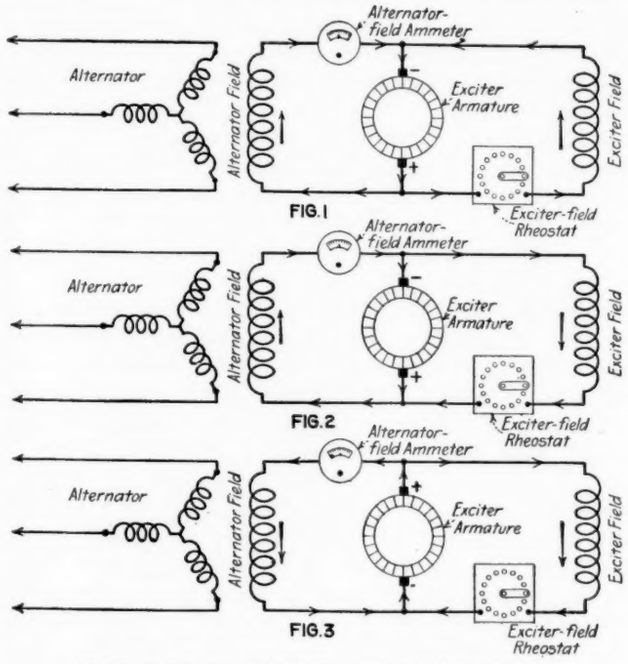
By M. A. Walker

SYNOPSIS—An explanation of how the polarity of an exciter directly driven from the alternator shaft may be reversed when taking the latter off the system, and what steps may be taken to prevent this trouble occurring.

A few years ago the direct-connected exciter driven from the same shaft as the slow-speed generators of that period was looked upon with disfavor because it represented such a large investment in apparatus, the dependence of one machine upon the other and the lower over-all efficiency compared with a few large exciters. The exciter mounted on the same shaft as the modern high-speed generator is now much in favor for both the large stations and the smaller ones. There are many advantages in using an exciter that is an integral part of the turbo-generator. The speed is high, which permits of efficient design and low unit cost; the arrangement is extremely economical of space, not for the exciter alone, but also for the wiring and control apparatus. The exciter pressure has to be changed to suit but one machine, the one it excites; hence a field rheostat in the exciter field suffices, thus obviating the necessity for a rheostat in the generator field, which is bulky, costly, extravagant of space, and decreases the over-all efficiency of the unit. The modern turbo-generator is so reliable that it can be treated as a complete station in itself, generator, turbine, boilers and auxiliaries being operated as one complete unit. This makes for high load factors, low labor costs and high over-all economy and efficiency.

But while these direct-connected exciters offer advantages that more than offset their disadvantages, their use has caused trouble in not a few instances. The reason is simple when once understood, but till then it arouses considerable speculation and misgivings among those operating them. The trouble is not really due to the exciter being direct-connected to the turbo-generator shaft, but to the improper choice of a field rheostat for an exciter having a definite saturation curve. The trouble usually occurs under conditions similar to the following:

As the load becomes light on the station—as, for example, after the peak-load period—the operator prepares to take a generator off the system by reducing the steam input to the turbine, at the same time reducing the field excitation and thereby the generator terminal voltage. The load on the generator has dropped almost to zero, and the operator prepares to work the oil switch controlling the generator, when suddenly the station-bus pressure drops from 15 to perhaps 50 per cent., or even more, depending on the total generating capacity in service and the relative capacity of the unit that was being cut out. Looking at the meters of the machine, the



FIGS. 1 TO 3. EXCITER AND ALTERNATOR FIELD CONNECTION

operator finds that the current has increased while the power-factor meter is still violently swinging. Believing that in reducing the voltage of the generator he must have cut in too much resistance, he starts to cut some out, thus bringing up the generator terminal voltage and to some extent the current. By the time the generator and station-bus pressure has been raised to normal, it has been discovered that the ammeter in the generator-field circuit is reading backward. In other words,

the exciter has changed its polarity since the trouble occurred, the change of polarity being what caused the severe drop in bus pressure.

The explanation of the phenomenon is briefly this: The generator when carrying only a very light load, such as it would immediately preparatory to taking it off the system, requires only a small current in the field to generate the no-load terminal voltage. Since the voltage of the alternator is controlled by varying the voltage of the exciter, the latter will be operating on a weak field, consequently on a steep section of the saturation curve; that is to say, where a small current increase or decrease gives a correspondingly large increase or decrease of the generator terminal voltage. All generator field windings constitute an inductive circuit, so that when the current flowing through them is suddenly changed, the inductance tends to prevent the change and maintains the current flow in the same direction, irrespective of the change, for a short period. If the steps on the exciter rheostat are very coarse and if the motor operating the rheostat has too rapid an action, it may cause the voltage variation of the exciter to be extreme. With this sudden and extreme drop of the exciter terminal voltage, the voltage across the generator field for a definite period of time is higher than that of the exciter and discharges back into the exciter circuit. The current of this discharge takes the path shown in Fig. 2, and is seen to flow from the alternator field through the armature of the exciter in the normal direction, but in the opposite direction through the exciter field winding, from that in Fig. 1, which shows the normal condition. The discharge from the alternator's field windings may suffice, not only to demagnetize but to actually reverse the residual magnetism of the exciter. The polarity of the exciter is then reversed, as shown in Fig. 3. Of course the reversal takes but a very short period, and by the time it has happened the operator is starting to cut resistance out of the rheostat with the intention of restoring conditions to normal.

Conditions That Cause Reverse Polarity

The trouble described may occur where the exciter operates at the steep part of the saturation curve, where the resistance steps in the field rheostat are large and will be augmented and more liable to occur when the rheostat arm travels fast. In all the cases brought to the writer's knowledge, six in number, the exciters were shunt-wound machines. This type of machine is usually employed for direct drive, because the load upon the individual generator is fairly steady and constant, therefore, does not require voltage compensation.

The remedy to prevent polarity reversal is to use an exciter that is less sensitive to current changes—that is to say, that works on a less steep portion of the saturation curve at light loads; although, by employing a rheostat that has closer gradations of resistance and that operates more slowly, the difficulty can often be overcome. Polarity reversals not only cause voltage variation, but may result in serious damage to the generators unless they have high internal reactance or external protection so that the current flowing into the machine without excitation may not exceed a safe value. Knowledge of what may happen and the exercise of greater care in lowering the voltage will go a long way toward preventing the occurrence of the trouble.

Entropy and Some of Its Uses—III

By F. R. Low

It takes an amount of heat proportional to the area *BCDLB*, Fig. 12, to evaporate a pound of water already at the boiling temperature, 358.5 deg., into a pound of dry-saturated steam at 150 lb. pressure. To evaporate a pound of water at 212 deg. into dry-saturated steam at atmospheric pressure takes an amount of heat proportional to the area *GKJEG*. To evaporate a pound of water at 100 deg. into a pound of dry-saturated steam at the pressure (0.946 lb.), at which that is the boiling point, would take an amount of heat proportional to the area *IMNOI;* and to evaporate a pound of water from and at 32 deg. would take an amount of heat proportional to the area *AOPFA*. Connecting the points C, K, M, O, we have the curve of saturation. The horizontal distance between this curve and the curve of the liquid *AB* (as along the dotted line between the 100- and 212-deg. levels) is proportional to the latent heat of evaporation at the temperature proportional to that level.

In the last article was considered the expansion of a pound of steam from 150 lb. to atmospheric pressure, in which case the change of state if the expansion were adiabatic would be represented by a movement from *C* to *H*.

During the expansion the pound of steam has partly condensed; and at the end of expansion the entire pound is at 212 deg., some of it water and some of it steam. The area *AGEFA* represents the heat necessary to raise the mixture from 32 deg. to 212 deg. The area *GHDEG* represents the heat necessary to evaporate as much of it

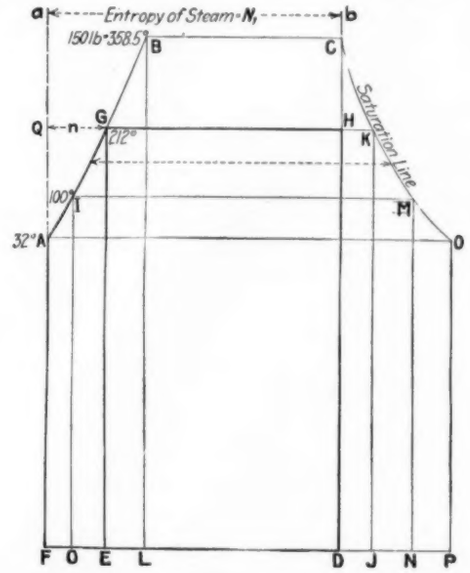


FIG. 12. REPRESENTS EXPANSION OF STEAM PLOTTED ON TEMPERATURE-ENTROPY DIAGRAM

as is still in the state of steam. But it would take an amount of heat proportional to the area *GKJEG* to evaporate the whole of it. The proportion of steam in the mixture is then the same as the proportion of the area *GHDEG* to the area *GKJEG*, or (since the areas are of equal height) as the proportion of the lines *GH* and *GK*.

The length of the line $QH = ab$ is proportional to the total entropy N_1 of dry-saturated steam at 150 lb. The line *QG* is proportional to the entropy of the liquid n_2 at 212 deg. The line *GH* then is proportional to their

difference, or $N_1 - n_2$. The line GK is proportional to the entropy of evaporation λ_2 at 212 deg. Since the proportion of steam in the mixture is the ratio of the line GH to GK, we have

$$\textit{Quality of the mixture} = \frac{GH}{GK} = \frac{N_1 - n_2}{\lambda_2}$$

$$= \frac{1.5992 - 0.3118}{1.4447} = 0.87$$

The values of N_1, the total entropy of 150 lb. dry-saturated steam; n_2, the entropy of the liquid at 212 deg.; and λ_2, the entropy of evaporation at 212 deg., are to be found in the steam tables. The calculation shows that if steam of 150 lb. absolute pressure is expanded to atmospheric pressure, or 212 deg., 87 per cent. of it—if it be dry-saturated to start with—will be in the form of steam at the end of the expansion and 100 — 87 = 13 per cent. of it will have condensed. This is usually expressed by saying that the quality of the mixture is 87 per cent., or 0.87, and that it contains 13 per cent. of moisture.

Operating Mechanical Stokers—V

By Warren O. Rogers

SYNOPSIS—Gravity-underfeed stokers are a combination of the underfeed-retort and the front gravity-feed types. Although each stoker of its type differs from the others, the general instruction presented herewith will on the whole apply to all.

There are several designs of gravity-underfeed stokers in which the grates incline from the front of the furnace toward the rear. Three stokers of somewhat similar design are the Taylor, Riley and Westinghouse, Figs. 1, 2 and 3 respectively. These are of the underfeed type in that the green coal is fed beneath the burning fuel. The gravity feature is due to the fact that the fuel bed is inclined, and the refuse from the fuel moves automatically out of the ignition zone as soon as the carbon

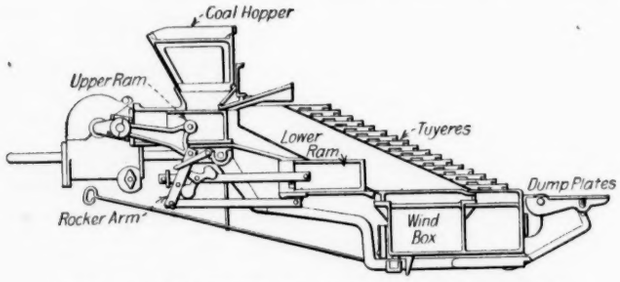


FIG. 1. FEATURES OF THE TAYLOR STOKER

is consumed. In these stokers coal is fed from the hopper into the fuel magazine, or retort, from which it is forced by a plunger into the coking zone of the furnace. Air, supplied by a fan, is carried to the furnace so as to pass between the openings of the tuyeres that form the tuyere boxes. Instruction for operating any one of these stokers will apply to a great extent to the others.

In starting up the front-feed underfeed stoker, if it is possible, feed coal from the hopper by running the stoker until there is three or four inches of coal over the tops of the grate blocks. If there is no steam to operate the stoker for this purpose, shovel the coal in by hand, and then put kindling and waste on top and turn on the draft until the fuel is thoroughly ignited. Keep the kindling near the front wall and the fire will soon spread toward the bridge-wall.

In starting up be especially careful not to get too heavy or too hot a fire on the ash plates. With some kinds of coal it may be necessary to put in ashes at the lower end of the stoker so as to prevent the danger of burning out, due to the fire being too hot. The lower end of the stoker is only meant to carry partly burned fuel with a large percentage of ash in it, and is not meant for a new hot fire of fresh fuel, therefore be careful when starting up. Do not open the dampers for overfeed air until there is plenty of ashes on the extension grates and ash plates, otherwise there may be too hot a fire in the lower end of the stoker.

As a matter of course the gear boxes will require watching for the first few days of operation. The proper method is to run for a few days, say three or four or until the temperature stops going up, then thoroughly clean out the gear box and put in new oil; any good, thick oil will do. If heating is excessive, renew the oil and clean out the box with kerosene or gasoline, several times if necessary. All gear boxes should run cool as soon as the surfaces are smoothed up and the dirty, gritty oil is replaced by new. Keep enough oil in the box to nearly cover the top of the speed wormwheel. If no cylinder oil is available, use a mixture of grease and oil.

In a case of emergency, when it is necessary to get the fire out of the furnace as quickly as possible, the best

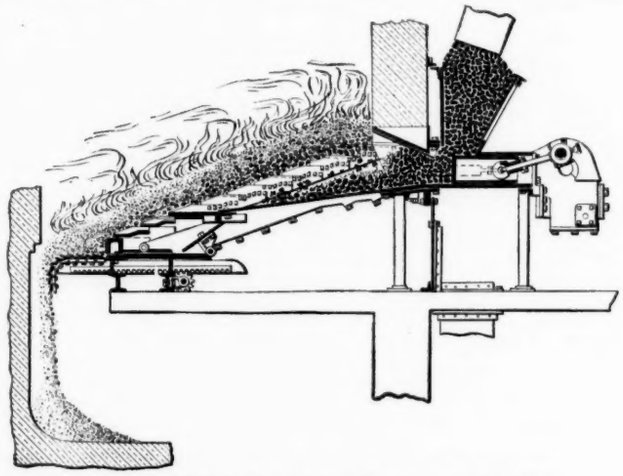


FIG. 2. SECTION THROUGH RILEY STOKER

method is to close the air blast and leave the stack damper open, open the dump plate and deaden the fire with a hose, and then push it into the ashpit where it may be killed. The water, however, should not be allowed to touch the brickwork.

See that the ashpit is tight and that its discharge mechanism is easily operated. Also be sure that the water-cooling pipe is equipped so that in case of dumping hot refuse, water may be turned on.

Do not keep the ash discharge open any wider than necessary to allow ashes to fall through. The best condition is to keep this closed so as to maintain a bridge of ashes over the opening and a thick bed of ashes on the ash plates so as to protect them from injury. Be careful to keep the ash hopper or ashpit clear of hot refuse so as to prevent overheating of the ash plates and racks.

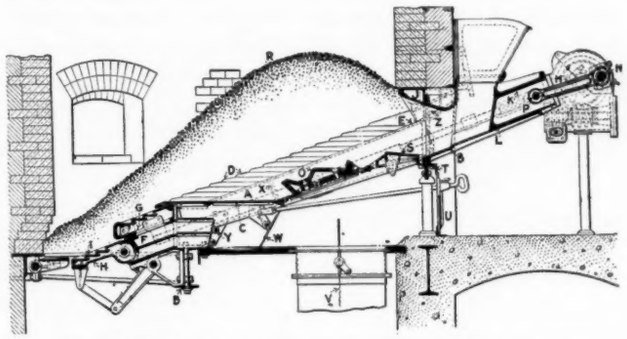


FIG. 3. SECTION OF THE WESTINGHOUSE STOKER

If necessary to dump hot refuse, be sure to turn on water in order to quench the fire in the ashpit.

In case of large clinkers that will not readily dump, it will be necessary to withdraw the ash support plates temporarily in order to let them through. If they are stuck to the bridge-wall or otherwise blocked, do not use a bar, but change the travel of one pusher nose opposite the clinker (Riley stoker). To do this effectively, put on the maximum travel of about 5 in. and let the pusher nose operate this way just long enough to break up the clinker properly. One or two strokes may do this. Do not leave this long travel on any longer than it is necessary, because otherwise it will bring down too much green fuel from the upper end of the stoker.

When ready to bank the fires, first shut off the air entirely and then push in coal until the required depth of bank is obtained. This will depend upon the length of time the stoker is required to stand. Do not use much travel, if any, on the side bars when banking fires.

Care should be taken in banking fires not to allow the fire to burn down to the tuyere plates and air box and injure it. If the air box becomes badly cracked, it will allow fuel to get into it, where it will burn and further injure the metal. When banking for more than 24 hours, more coal must be pushed in to keep the fire from burning down to the cast-iron tuyere plates and air box.

When it is desired to raise steam from a banked fire, turn on the air and then start the side bars with their minimum travel. If the fuel bed is heavy, run the stoker with the hopper empty so as not to feed in any more fuel until after the side bars have broken up the bed and it has had a chance to burn down to normal thickness.

When starting with a new fire, the dump plates should be closed. There should not be more than one or two inch space from the end of plates to the bridge-wall. After operating for an hour or an hour and a half, depending on how hard boiler is being run and on the grade of coal being burned, the ash plates (Riley stoker) should be opened one section or slightly more, depending on the conditions of the fuel at the back of the fire. Then after a space of two hours, open the same amount as before and repeat this after another time period of the same length. Then by putting an extra stroke adjuster on the side bars, the tail end of fire will drop down in the ashpit. The time interval may have to be varied to meet special conditions.

The principle is that as a fire gets older it also gets dirtier, hence a gradual opening of ash plates with a corresponding discharge will keep a practically clean fire. If this is followed out, there will be no piling up of hot material along the bridge-wall to cause clinkers. It is important that the side bars always have at least one stroke adjuster on to obtain an ideal cleaning condition, but do not give them enough travel to dump any unburned fuel.

A difficulty that is experienced with some types of underfeed stokers is from clinkers adhering to the side walls of the furnace. Although these stokers are automatic in the cleaning process, the attendant's duties being to periodically operate the dump plates, there are coals that form such clinker that it is desirable to resort to a bar with a chisel point so that it can be driven between the clinker that sometimes forms over the tuyere plates. Care should be exercised that the brick side walls are not injured in removing the clinker.

Under some conditions a slice bar for cleaning of soft clinkers and for breaking up the fire can be used to advantage.

It is the practice of some engineers, in order to overcome the breakage of gears and other important parts of stokers, such as might result from the clogging of the rams, to reduce the diameter of the bolts holding the

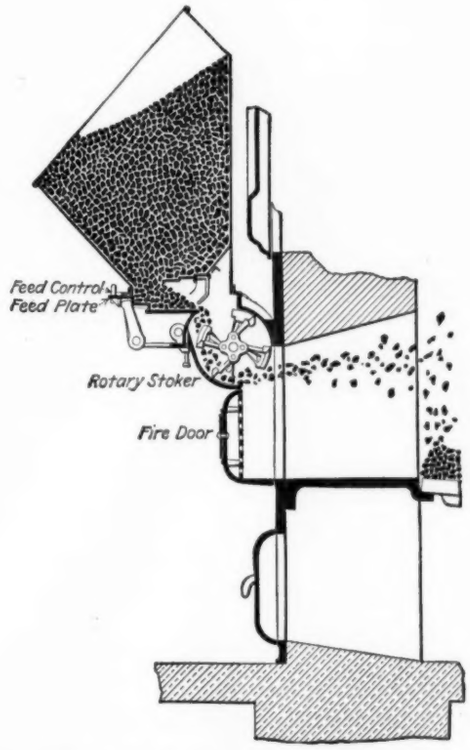


FIG. 4. THROW TYPE OF STOKER

bearing caps to $\frac{3}{8}$ in., or about 30 per cent.; this in addition to the safety pins in the gearing. In case of the rams clogging, the bolts will shear, warning the fireman and also preventing serious damage to the stoker itself. Steps can then be taken to remove the ram obstruction. The failure of the bolts requires the stoker to be stopped but a few minutes.

A number of small-sized stokers suitable for small boiler installations have recently been designed. One of the throw-stoker type (Swift) is shown in Fig. 4.

In handling the class of stokers that throw the fuel into the furnace by means of a revolving member, it should be kept in mind that, in principle, the operation gives a light uniform feed of coal at the same rate as it is burned. The fire-doors permit access to the fire for observation and for the correction of any irregularity in the working of the fire bed due to clinker.

When a clinker forms on any part of the grate, its presence is shown by a darker and thicker area caused by the lack of air and by coal on that portion of the bed not burning down as fast as on the rest. The operator can remedy this condition by removing the clinker with a hook and patching the spot with fresh coal placed with the shovel. Do not attempt to patch by raking live fire over the spot, as to do so invites another clinker at the same place. A characteristic of the operation of this type of stoker is that it carries a thin fire, and this should be disturbed with the fire tools as little as possible.

It may be necessary occasionally to remove an accumulation of fine fuel from the dead plate. To do this move part to the front corner of the grate and part behind the pier between the stoker openings. Never shove this material to the center of the fire.

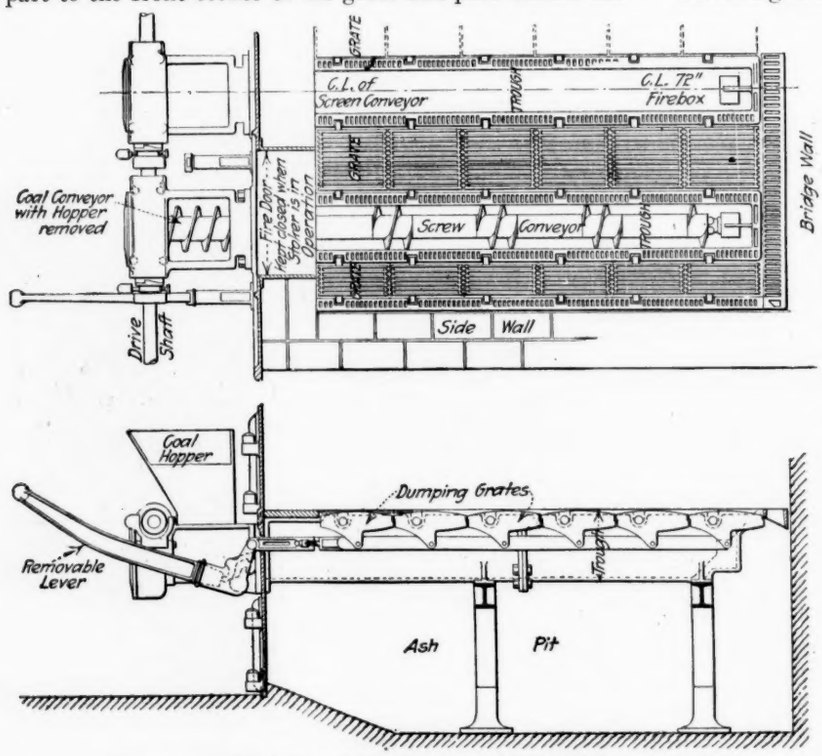


FIG. 5. PLAN AND SIDE VIEW OF THE STEVENS STOKER

Feeding with the stoker should not be started until the fire bed is in a level condition and admitting air uniformly. The equipment will then maintain the bed in a level condition.

If rocking or dumping grates are used, do not rock them violently enough to mix the fire and ashes; this will make clinker or may let patches of fire fall through the grate.

Since the fuel is spread on the fire every few seconds, a comparatively small change of the feed-control screw, one turn or one-half turn, makes considerable difference in the quantity of fuel supplied. Therefore, when increasing the feed to take care of a large increase in the load, the right way to operate is to give the feed-control screw one turn at a time and wait two or three minutes before giving it another turn.

Increasing the feed at intervals this way allows time for the furnace to change the rate of combustion most effectively and without smoke. It is also easier using this method to determine when the rate of feeding is sufficient to carry the load.

When the steam pressure is too high and it is necessary to stop feeding to avoid blowing off steam, in addition to throwing out the link controlling feed regulation, the ashpit door should be closed. This stops the supply of air to the bed and holds the fire in practically a banked condition with less heat waste. When the high-pressure period is past, the fire bed will be hot and ready to take the fuel feed again. If necessary to stop the furnace operation for some time, the damper in the breaching should be nearly closed to check air infiltration, etc. On light loads reduce the draft with the dampers.

Screening when extremely dry should be moistened to some extent but not soaked; when coal is extremely wet, the hoppers should be observed occasionally to see that the coal is not hanging and thus preventing the regular feeding of fuel. Fires are started, cleaned and banked in practically the same manner as in ordinary hand firing. A design of underfeed stoker having a combination of worm feed and dumping grate is the Stevens, Fig. 5. The coal hopper is removable, and hand firing can be carried on in case the stoker becomes deranged by removing the hopper. The apparatus comprises a trough or troughs, according to the size, open at the top and extending from a short distance outside the boiler front to the rear of the furnace. In the bottom of each trough is a screw conveyor which is driven from the outer end by a worm gear and worm, the latter being driven by a small steam engine or motor. As the screw conveyor revolves, the fuel is spread evenly over the grate surface. When starting a new fire, cover the grates and conveyors with coal and ignite with a wood fire built at the front of the furnace. Hand firing can be resorted to until steam has been raised, in the case of a single boiler. If steam is at hand for operating the stoker driveshaft, coal can be fed into the furnace at intervals through the stoker, until the fire covers the grates thoroughly. As with any other stoker, the fire should not be forced under a cold boiler. When the fire is burning properly, the stoker can be started by throwing in the clutch on the drive shaft.

The thickness of the fires carried is governed by the speed of the stoker drive. When the demand for steam falls off, as would be the case when shutting down the engine the stoker clutch is thrown out of gear.

When cleaning fires, draw the live coals forward onto the front section of grates, and then dump the ashes and clinker on the rear section into the ashpit. Next push the live coals from the front section back upon the rear grates and dump the refuse into the ashpit. The live coals are then evenly spread over the surface of the section of grates thus cleaned. When all grate sections have been cleaned, the stoker is started and operated until the fires again require cleaning. This period will depend upon the character of the coal being burned.

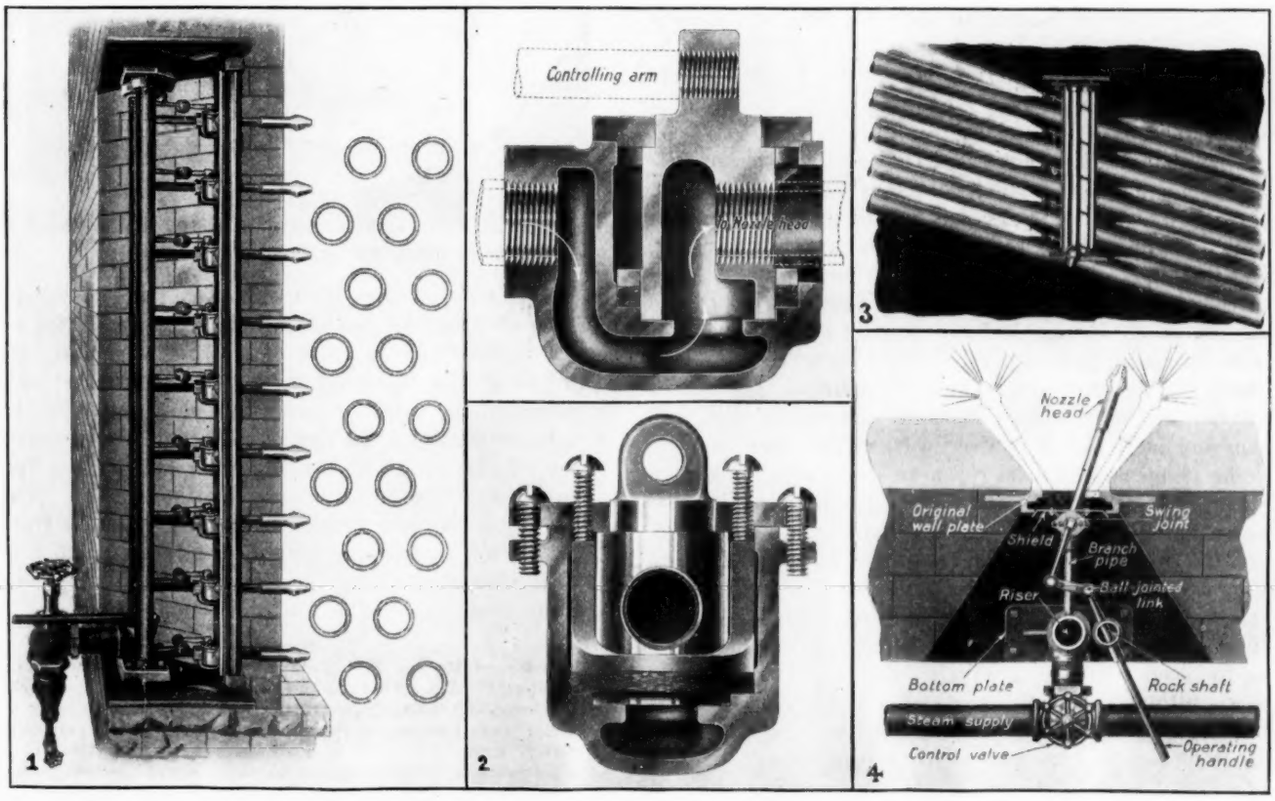
When about to bank the fire, allow it to burn down somewhat and then push the live coals back against the bridge-wall and spread again when starting up. Separate doors are provided in the boiler front, and on each side of the stoker hopper is a small door for observation and for leveling the top of the fire when necessary.

Bayer Steam Soot Blower

The Bayer type B soot blower is designed for removing soot and fine ashes from the heating surfaces of vertically baffled water-tube boilers. It is made up of distinct units for each pass or compartment, equipped with as many nozzles as there are spaces between the tubes. The nozzles, which are collectively under the control of a lever within reach of the floor, are given an oscillating motion following the plane of the tubes. Jets of steam from each nozzle flow horizontally into the opposing opening between the tubes for the full length of the pass, and by direct force and expansion of the steam, loosen the soot and ash particles from the heating surface. The units are designed so that they will fit the cleaning pockets originally provided along the side walls for hand cleaning. Each element receives steam from a common supply leading from the superheater or from the top of the main steam header, the supply line passing below the blowing units and having a drain at the lowest point to insure dry steam for the blowing operations.

Reference to Fig. 1 will show the construction of one of these units and indicate how the furnace wall is built up to deflect the hot gases and prevent deterioration of the nozzles. Fig. 3 shows the steam being projected into the planes between the boiler tubes, this being accomplished by making the axes of rotation perpendicular to the pitch of the tubes.

Fig. 4 is a section through the blower unit indicating the mechanism used to impart an oscillating movement to the nozzles; the unit has a centrally located riser connected to the steam line. Short branches, one for each nozzle, extending inward, connect the riser with swing joints, the moving members of which connect through nipples to three-way nozzle heads within the furnace walls. A vertical rockshaft located at the side of the riser and provided with a single operating handle connects with the moving members of the swing joints through sets of links and levers. Thus the motion of the operating handle is imparted to the entire series of nozzle heads, and after the steam has been turned on, three separate jets from a standard nozzle will sweep the opposing space between the tubes for the full length of the pass. The main jet issues from the end of the nozzle, while the two sidewise jets are smaller and therefore auxiliary. Special types of nozzle are supplied, depending upon the service requirements. In the limiting position at either side the nozzle heads are brought back nearly flush with the furnace walls, so



FIGS. 1 TO 4. DETAILS OF BAYER STEAM SOOT BLOWER

Fig. 1—Blower unit inserted in first pass. Fig. 2—Side and end sectional elevations of Bayer swing joint. Fig. 3—Steam projected in planes parallel to the boiler tubes. Fig. 4—Section through cleaning pocket, showing oscillating mechanism

that they are out of the strongest current of the combustion gases and are therefore protected when out of service.

The swing joint is shown in Fig. 2. Steam enters through a cored channel, passes up through the bottom into the movable part and into the nozzle-head pipe. The only movable part is the one that connects the controlling arm with the nozzle pipe, and here steam-tightness is maintained by a stuffing-box and packing adjusted by the pressure of two screws upon an internal gland. The joint admits of being brought squarely up against and bolted to the cover shield that closes the cleaning pocket. This is done through an extension flange on the stationary joint member that makes the connection air-tight. Inside is a chamber amply large to permit the free swing of the nozzle head pipe through a wide arc. The swing joints are set so that their axes are at right angles to the pitch of the boiler tubes. Ball joints on each end of the connecting links prevent binding action in the lever system due to the inclination at which the nozzles are set.

This soot blower is manufactured by the Bayer Steam Soot Blower Co., St. Louis, Mo.

Adjusting an Inertia Governor

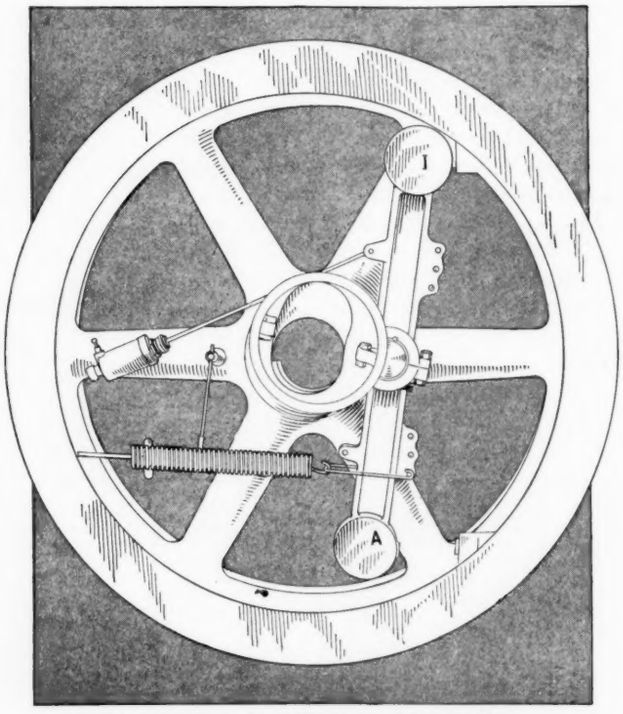
By J. Lewis

The adjustment of inertia governors sometimes proves puzzling when undertaken for the first time. The bar, pivoted at the center and extending as it does across the wheel and having weights at both ends, would seem to work against itself. Each weight tending to fly, by centrifugal force, toward its stop, and this force being proportional to the weight at each end, it follows that weight *A*—which may be called the active weight—must be heavier than *I*, the inertia weight, to cause the arm to assume a different position for different rates of rotation; and it must also be enough heavier to counteract the tension of the spring shown. If the inertia end of the arm were removed, the remaining parts would then act as a simple centrifugal governor.

The characteristic action of the inertia governor differs from the centrifugal type and is more noticeable in starting up, in that if steam is turned on suddenly, both weights tend in the same direction, are inert or lag, and the force tending to compel them to keep up with the motion of the wheel is the spring. Therefore with little tension on the spring and the weights nearly equal and with the crank just past the center, the wheel may leap ahead on the first stroke and the weights lag behind, leaving the valve almost stationary, aided by the friction and inertia of the valve itself, so that there is little or no steam admitted on the next stroke and the engine slows down, the spring overcomes the inertia, the arm again approaches the position of maximum valve travel and the engine again surges forward. This cycle of action may occur at each revolution or at more or less regular intervals as the engine speeds up, and with a relatively light flywheel and no load, will be more pronounced, but as the load comes on gradually, the motion will steady down, although sudden changes of load will set up "hunting" again. The dashpot is intended to steady the governor motion to a certain extent, but its action must not be so great as to interfere with its sensitiveness.

One of two things may be done in this case; namely, reduce the weights so that the spring can drag them along without undue inertia effect or strengthen the spring proportionately to the weights. The tension on the spring, if already adjusted to the desired speed, obviously cannot be increased, so its flexibility must be changed by shortening it. This is done by advancing the wing-nut held between the coils into which the end of the adjusting screw engages and readjusting the tension to suit the speed. This means is probably the best to use in general, shortening only one or two coils at a time until the behavior is satisfactory, keeping in mind that the tension screw must be let out an equal amount.

The other procedure is to take out one or more weights from each end pocket. This, however, may disturb the balance of the wheel and also the "inertia balance," besides reducing the power of the governor over the friction of the valve and connections. It should be borne in mind that the governor arm performs the same function, or does the same thing, for the valve as the flywheel does



ONE TYPE OF INERTIA GOVERNOR

for the piston—steadies its motion—so that its weight must be ample. An interesting study of the action of such a governor (on a spare engine) is to remove one weight at a time and slacken the spring tension until the action of the governor shows that the friction of the valve is too great for the flywheel effect of the governor arm, when the valve action will be decidedly erratic and tightening a stuffing-box even may disturb its action. The engine speed may be increased by removing weight from the active end *A* or adding weight to the inertia end *I* of the arm without changing the tension of the spring, but with the foregoing caution.

Capacity of Engine Not Warranted—The mere description of an engine in a contract of sale as "one 30-hp. simple traction engine" did not constitute a warranty on the part of the seller that the engine would have any certain capacity, especially where the presence of express warranties, that the engine was of good material and equal to or better than any other engine of equal size and proportions when property handled, negatived any intent to warrant any specific power. (California District Court of Appeal, J. I. Case Threshing Machine Co., vs. Copren Brothers, 162 Pacific Reporter, 647).

Steam-Engineer's License Examination—XII

By H. F. Gauss

SYNOPSIS—Determining mean effective pressure in an engine cylinder by the ordinate method or by the use of the planimeter. Indicated and brake horsepower and how the latter may be determined by the use of a prony brake.

In the reciprocating steam engine, work is done by the steam acting on a moving piston. This can be divided into two stages, consisting of boiler pressure (minus pipe-line friction) up to cutoff and a gradually falling pressure due to expansion in the cylinder after cutoff. The work done by the steam during one stroke is equal to the average pressure per square inch multiplied by the area of the piston in square inches and by the length of the stroke in feet. The work done per minute is the work per stroke multiplied by the strokes per minute. Since the pressure in the head end acts over the entire area of the piston head, while that in the crank end acts over the same area minus the sectional area of the piston rod, it follows that, with the same mean effective pressure, the work done in each end will not be the same. Instead of computing the work done in each end separately and adding it together, it is customary to use a mean piston area found by deducting from the piston area one-half of the area of the piston rod.

$$Work\ per\ minute = P \times L \times A \times N$$

where

P = Mean effective pressure in pounds per square inch;
L = Length of stroke in feet;
A = Mean area of piston in square inches;
N = Strokes per minute, or twice the revolutions per minute.

All the above quantities are easily determined except P, the mean effective pressure, to find which the pressure on both sides of the piston must be determined at every point in the stroke. The effective pressure at any instant is, then, the pressure on one side minus the back pressure on the other side, and the mean effective pressure is the average of all the instantaneous effective pressures.

The steam-engine indicator is employed to measure the pressure on each side of the piston throughout the stroke, and consists of a small cylinder containing a steam-tight piston that rises against an accurately calibrated spring. The lower side of the cylinder communicates with the clearance volume in the main engine cylinder, hence the pressure on the indicator piston is at all times the same as that on the engine piston. In moving against the calibrated spring, the indicator piston operates a system of compensating levers that cause a pencil to move exactly parallel to the motion of the piston itself, but multiplying the motion of the piston so that one inch of the pencil motion represents a certain number of pounds per square inch of pressure on the spring. The pencil presses against a drum whose axis is parallel to the axis of the spring and which is caused to revolve by the reciprocating motion of the engine. The motion of the engine is transmitted to the drum by a reducing gear in such a way that the motion of a point on the surface of the drum is proportional to the motion of the engine piston. The indicator drum is arranged to hold a card of paper on which a diagram is drawn by the pencil, the diagram showing exactly the pressure on the piston at all points of the stroke.

Fig. 1 shows two indicator diagrams taken simultaneously—one from the head end and one from the crank end of a steam engine. The line AB indicates zero gage pressure, or it is the atmospheric line. It is seen that the back pressure is a few pounds above atmospheric. The line of zero absolute pressure CD is drawn at a distance below AB equal to the pressure of the atmosphere, as shown by the barometer. One atmosphere can be taken as 14.7 lb. without appreciable error. Since the standard steam tables are based on absolute pressures, it is always well to draw the line of zero absolute pressure on the indicator card.

As the piston travels from the head end of the cylinder to the crank end, the pressure per square inch pushing it forward is represented by the line abc, while the back pressure is given by the line fgd. The effective pressure at any point x in the stroke is nx-nx'. At y the forward pressure and the back pressure exactly balance, making the effective pressure zero. At z the forward pressure is less than the back pressure and the effective pressure is negative, being given by mz'-mz. The engine is carried over the center by the momentum of its flywheel.

With compression starting at the same point in each end of the cylinder, the average back pressure should be the same for each stroke. The mean effective pressure is the average forward pressure minus the average back pressure and can be determined, as it usually is, from a

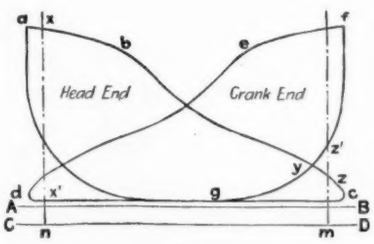


FIG. 1. EFFECTIVE PRESSURE FROM INDICATOR DIAGRAMS

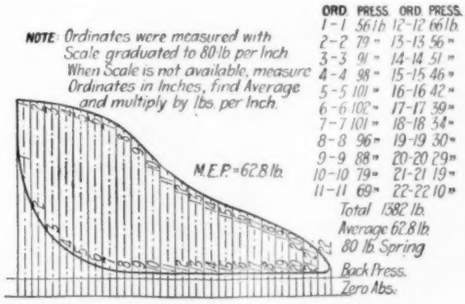

NOTE: Ordinates were measured with Scale graduated to 80 lb per Inch
When Scale is not available, measure Ordinates in Inches, find Average and multiply by lbs. per Inch.
ORD. PRESS. ORD. PRESS.
1-1 56 lb. 12-12 66 lb.
2-2 79 " 13-13 56 "
3-3 91 " 14-14 51 "
4-4 98 " 15-15 46 "
5-5 101 " 16-16 42 "
6-6 102 " 17-17 39 "
7-7 101 " 18-18 34 "
8-8 96 " 19-19 30 "
9-9 88 " 20-20 29 "
10-10 79 " 21-21 19 "
11-11 69 " 22-22 10 "
Total 1382 lb.
Average 62.8 lb
80 lb Spring
M.E.P.=62.8 lb.
Back Press.
Zero Abs.

FIG. 2. MEAN EFFECTIVE PRESSURE BY ORDINATES

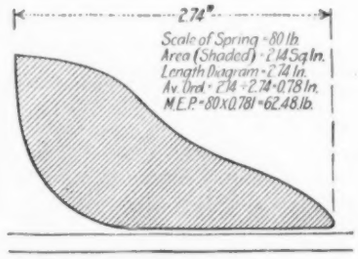


FIG. 3. MEAN EFFECTIVE PRESSURE BY AREA (REDUCED SCALE)

diagram taken from one end only of the cylinder by assuming the back pressure in each end equal. This mean effective pressure may be determined in two ways:

1. The length of the diagram can be divided into a number of equal parts and vertical lines drawn through each division. If the middle line, or ordinate, of each division be measured between the limits of the diagram and the sum of all divided by the total number of parts, the quotient will be the average height of the diagram, and if multiplied by the scale of the spring, will give the mean effective pressure. The greater the number of divisions the more accurate will be the result. See Fig. 2.

2. The area of the diagram in square inches may be measured by means of a planimeter and divided by the length of the diagram in inches. The quotient is the exact

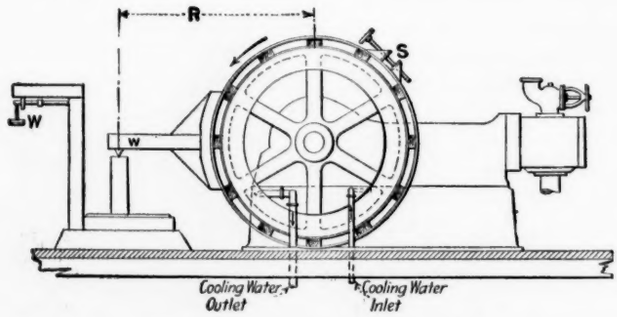


FIG. 4. CONVENTIONAL PRONY BRAKE

mean ordinate which, multiplied by the scale of the spring, gives the mean effective pressure. See Fig. 3.

It is practically impossible to so adjust the cutoff, or control the initial pressure, that the mean effective pressure during the forward stroke will be exactly the same as that during the return stroke. It is also impossible to maintain conditions so uniform that the mean effective pressure during successive strokes will remain constant. As a result, it is necessary to determine the mean effective pressure for a number of successive forward and return strokes, and the average of these, inserted for P in the formula $P\ L\ A\ N$ will give the work done per minute in foot-pounds.

By definition, a horsepower is equivalent to 33,000 ft.-lb. of work per minute, hence the indicated horsepower of an engine is given by the formula

$$I.Hp. = \frac{PLAN}{33{,}000}$$

This is all the work done by the engine and includes that necessary to overcome the friction in the cylinder and engine journals, plus that used in doing useful external work. The useful external work is expressed in terms of brake horsepower. It is determined by means of some form of brake or absorption dynamometer. The ratio of the boiler horsepower to the indicated horsepower is termed the mechanical efficiency of the engine.

The most common dynamometer is the prony brake. It consists of a lever attached to dynamometer brake blocks that can be applied to a pulley on the main engine shaft, or to the flywheel if it is not too large. The end of the lever carries a knife-edge which rests on a suitable scale. As the brake around the pulley is tightened up, the lever presses down on the scale and the amount of the pressure can be determined by weighing it directly.

Fig. 4 shows a prony brake applied to a 10-hp. engine. The dimensions and quantities that must be measured to arrive at the brake horsepower are indicated. In the drawing, R is the distance in feet from the center of the engine shaft to the knife-edge on the lever, W is the load on the scale in pounds and w is the net weight of the part of the brake supported by the scales when the engine is standing still with the brake loose. The brake horsepower can then be determined by the formula,

$$B.Hp. = \frac{2\pi R(W - w)N}{33{,}000} = \frac{R(W - w)N}{5252}$$

In this case N is the number of revolutions per minute. When determining the brake horsepower, the load on the scales must be kept constant by adjusting the brake screw S.

During a brake test on an engine, all the external work done is against the friction between the brake and the pulley rim and appears as heat that must be radiated and conducted away. The heat generated is exactly equivalent to the work done, and since one unit of heat (one British thermal unit) is equivalent to 778 ft.-lb., there are in a horsepower 42.42 units of heat per minute, or 2545 units per hour. A 20-hp. engine would produce 50,900 heat units per hour in friction on the brake, which is as much heat as can be obtained by burning four pounds of good coal.

To get rid of this heat and prevent the brake blocks from catching fire, some cooling device must be used, such as a sheet-iron flange on each side of the brake pulley, or flywheel, making a trough inside the wheel about 2 in. deep, as shown in Fig. 4. Water admitted to this trough in a steady small stream is held out against

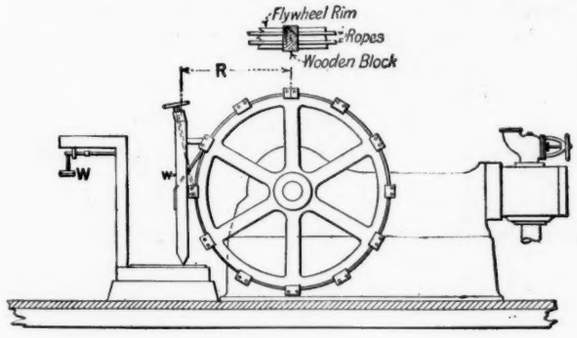


FIG. 5. THE ROPE BRAKE

the periphery by centrifugal force. A scoop can be arranged to remove the water at the same rate at which it is admitted.

Another form of brake commonly used where the power to be measured is comparatively small, say less than 50 hp., is the rope brake. It is similar in all respects to the prony brake, the brake band being composed of two strands of rope fastened to wood blocks at regular intervals and arranged to pull down on a vertical pedestal resting on a platform scale. This form of brake is shown in Fig. 5. The computations are the same as for the prony brake.

For measuring larger powers there are a number of different types of brake but no better form of dynamometer can be found than the electric generator, the output of which can be kept constant by banks of lamps or some form of rheostat.

Frosted Glass, useful for screens, etc., is made by laying sheets horizontally and covering them with a strong solution of sulphate of zinc. The salt crystallizes on drying.

Tests of Atmospheric Ammonia Condenser

By G. H. Crawford

SYNOPSIS—Gives the results of a test to determine the performance of an atmospheric counter-current ammonia condenser against an atmospheric parallel-flow condenser.

The meager data published concerning the performance of ammonia condensers leads me to submit the results of a series of operating tests which I recently conducted on an atmospheric ammonia condenser. These tests were made to determine whether or not a condenser installation was meeting its guarantees.

At the plant of L. Michel, Brooklyn, N. Y., it was decided to replace a battery of ten stands of worn-out condensers, each 24 pipes high. These machines were of the atmospheric parallel-flow type. The new condensers,[1] Fig. 1, have ten stands of 12-pipe atmospheric counter-current condensers sold under the following guarantee: "With 35 gal. of 55-deg. water per minute per stand, we will guarantee that these condensers (10 stands) will show a refrigerating capacity of 175 tons. If a larger quantity of water is supplied, the condensers will have a greater capacity."

The new condenser stands were arranged as shown in Fig. 1. The hot gas from the compressors entered the bottom pipe, each stand meeting there the warmest waste water from the upper pipes, thereby losing its superheat and approaching saturation temperature. As the gas ascended the pipes, it was condensed by the cooling of the coldest water and passed out through the "bleeders" placed on the sixth and tenth pipes. In this way the liquid ammonia was supercooled below the saturation temperature.

TABLE I. DATA OF OPERATING TESTS

	B	C	D
1. Head pressure, lb. per sq. in	161	163	160
2. Back pressure, lb. per sq.in	20	15	14
3. Speed, r.p.m	43	44	43
4. Displacement of machine per min., cu.in. per ton	6,945	8,250	8,480
5. Capacity of condensers, tons	202.0	174.0	165.5
6. Stands in use	10	7	6
7. Tons per stand	20.2	24.8	27.6
8. Temperature of water on, deg. F	55.5	55.0	55.5
9. Temperature of water leaving, deg. F	83.0	85.0	85.0
10. Temperature difference, deg. F	27.5	30	29.5
11. Pressure corresponding to off temperature, lb. per sq.in	147.6	153.2	153.2
12. Temperature corresponding to head pressure, deg. F	87.7	88.4	87.4
13. Excess temperature, deg. F	4.7	3.4	2.4
14. Water per stand, gal. per min	15.0	.....	19.5
15. Degree, gal. per min. per stand	412	.....	575
16. Degree, gal. per min. per ton refrigeration	20.4	.....	20.8

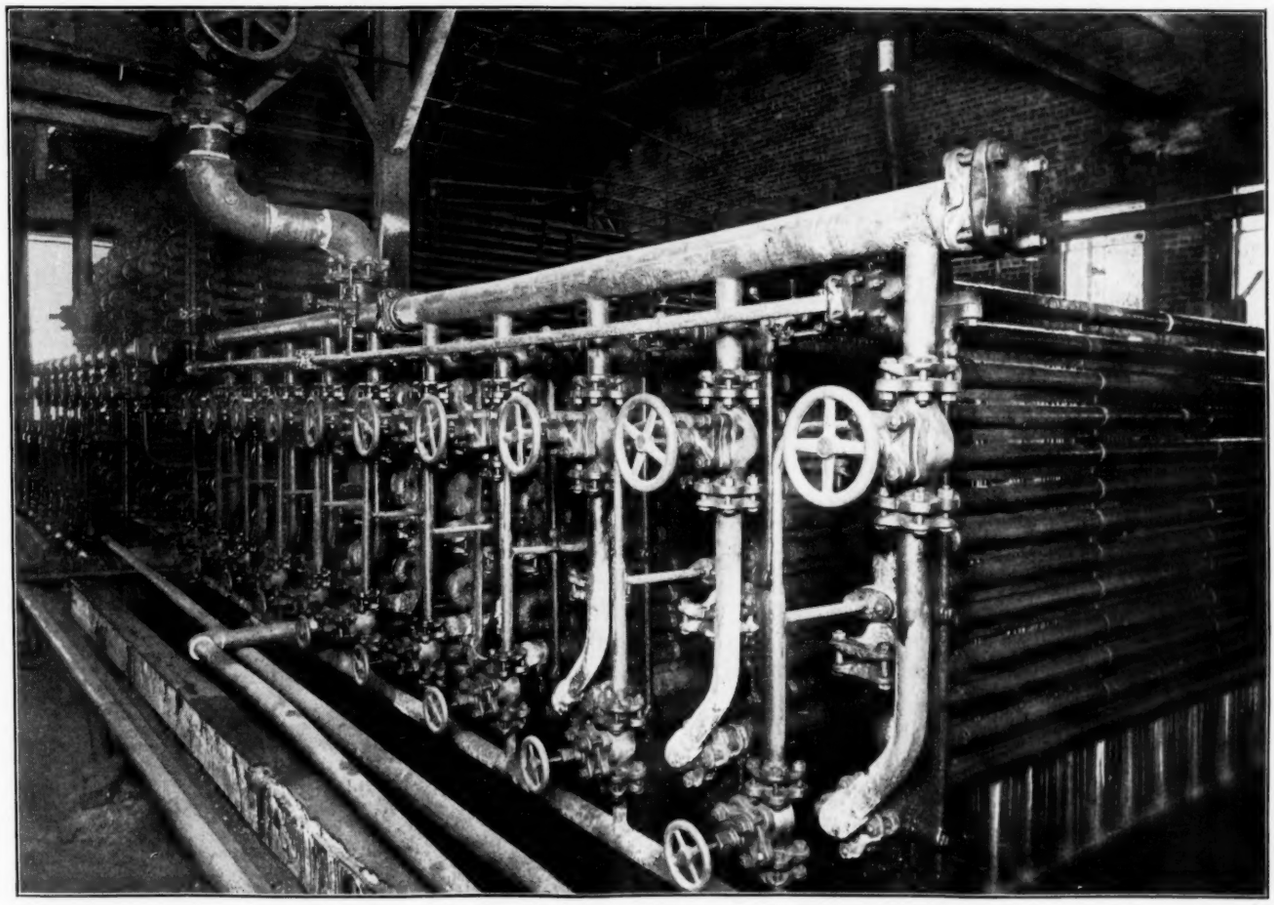


FIG. 1. COUNTER-CURRENT ATMOSPHERIC AMMONIA CONDENSERS IN FOREGROUND

During the test load was placed on these condensers by means of a York two-cylinder vertical single-acting machine, each compressor being 24 in. diameter by 36 in. stroke. At first the machine was pumping to ten stands, then to seven, and finally to six.

[1] De La Vergne.

A summary of the results from three tests are shown in Table 1:

Items 1, 2 and 3, 6, 8 and 9 are from the original data.

Item 4 is interpolated from a table giving displacements and capacities of York single-acting machines, as per Table II.

Item 5 is calculated from the displacement of the compressor and from item 4.

Item 7 is calculated from items 5 and 6.

Item 10 is calculated from items 8 and 9.

Item 16 is calculated from items 7 and 15.

The results of these tests are interesting. The tonnage per stand (item 7) is much above the guarantee, yet the excess temperature (item 13) is very low. This item, the excess temperature (difference between the actual temperature of water leaving condenser and the temperature corresponding to the condensing pressure), is a valuable index to condenser performance and is often overlooked. A high tonnage per stand is not desirable when it is accompanied by a great excess of pressure over that due to temperature of leaving water. The economy in the use of water for this style of atmospheric condensers also is of interest.

In the background of the illustration is seen a battery of 24-pipe parallel-flow condensers similar to those replaced by the new ones.

TABLE II. DISPLACEMENT AND HORSEPOWER PER TON OF REFRIGERATION, DRY COMPRESSION

From York Manufacturing Co.

Condenser Gage Pressure and Corresponding Temperature = Temperature of Liquid at Expansion Valve	S. A. Single Acting D. A. Double Acting	Suction Gage Pressure and Corresponding Temperature: 5 lb. = — 17.5 Deg. F. — Volumetric Efficiency per Cent. of Displacement	5 lb. = — 17.5 Deg. F. — Cu.in. Displacement per Min. per Ton of Refrigeration	5 lb. = — 17.5 Deg. F. — I. H. P. per Ton (Comp.)	10 lb. = — 8.5 Deg. F. — Volumetric Efficiency	10 lb. = — 8.5 Deg. F. — Cu.in. Displacement	15.67 lb. = 0 Deg. F. — I. H. P. per Ton (Comp.)	15.67 lb. = 0 Deg. F. — Volumetric Efficiency	20 lb. = 5.7 Deg. F. — Cu.in. Displacement	20 lb. = 5.7 Deg. F. — I. H. P. per Ton (Comp.)	20 lb. = 5.7 Deg. F. — Volumetric Efficiency	25 lb. = 11.5 Deg. F. — Cu.in. Displacement	25 lb. = 11.5 Deg. F. — I. H. P. per Ton (Comp.)	25 lb. = 11.5 Deg. F. — Volumetric Efficiency	30 lb. = 16.5 Deg. F. — Cu.in. Displacement	30 lb. = 16.5 Deg. F. — I. H. P. per Ton (Comp.)
145 lb. = 82 deg. F.	S. A.	79.	12,608	1.654	81.2	9,811	1.4	83.	7,829	1.195	84.2	6,765	1.065	85.5	5,836	.943
145 lb. = 82 deg. F.	D. A.	68.	14,645	1.921	70.5	11,300	1.612	73.	8,901	1.358	74.7	7,625	1.2	76.5	6,522	1.054
165 lb. = 89 deg. F.	S. A.	77.5	13,045	1.834	79.7	10,148	1.56	81.5	8,092	1.341	82.7	6,990	1.201	84.	6,027	1.071
165 lb. = 89 deg. F.	D. A.	66.5	15,203	2.137	69.	11,720	1.802	71.5	9,224	1.529	73.2	7,898	1,357	75.	6,751	1.2
185 lb. = 95.5 deg. F.	S. A.	76.	13,491	2.013	78.2	10,487	1.72	80.	8,362	1.4865	81.2	7,219	1.336	82.5	6,223	1.197
185 lb. = 95.5 deg. F.	D. A.	65.	15,774	2.354	67.5	12,150	1.993	70.	9,555	1.7	71.7	8,176	1.513	73.5	6,985	1.344
205 lb. = 101.4 deg. F.	S. A.	74.5	13,947	2.192	76.7	10,834	1.879	78.5	8, 30	1.631	79.7	7,450	1.47	81.	6,420	1.323
205 lb. = 101.4 deg. F.	D. A.	63.5	16,362	2.571	66.	12,590	2.184	68.5	9,890	1.87	70.2	8,459	1.67	72.	7,222	1.488

Items 11 and 12 are calculated from ammonia tables.

Item 13 is calculated from items 9 and 12.

Item 14 is based on quantity of water, determined by measuring the height of water in water distributing boxes—necessarily approximate.

Item 15 is calculated from items 10 and 14.

Transmission-Line Formula

By E. M. Richards

SYNOPSIS—A formula is given for making the calculation involved in the design of direct-current transmission systems. Although this formula does not give absolutely correct values, the results so derived are close enough for all practical purposes.

The calculations involved in the design of transmission lines with a number of parallel resistances are long and tedious, with the methods commonly used. It is customary for direct-current systems to apply Ohm's and Kirchoff's laws at one end of such a circuit, and to use these laws successively on each individual parallel resistance throughout the system. The author has never been able to find a formula that obviates this lengthy process, and in an effort, therefore, to considerably shorten the time of these calculations, after finding that the deduction of a formula by calculus or series is almost hopeless, has algebraically derived a formula for a direct-current transmission line from a curve approximating a uniform-voltage parallel-resistance curve of a direct-current circuit, and modified it with constants in order to produce results in conformity with the customary lengthy calculation. This empirical formula gives closely approximate results. It applies to a number of equal resistances in parallel, having equal line resistances between each pair of parallel resistances. While this equality of resistances is not often found in general service, close results may be obtained by using an equivalent equal parallel resistance and an equivalent equal line resistance.

In the following examples the formula gives results that vary from the theoretical accurate results from zero to a small percentage. A small variation is readily permissible in design because a larger margin must often be given to allow for variation in workmanship, material, character of installation, etc. The higher the ratio of equal parallel resistance to the line resistance between a pair of parallel resistances, the more nearly accurate the formula. In service this ratio is generally high.

While this formula can be extensively used in calculating transmission lines, for lighting systems, electro-pneumatic brake equipment, etc., nevertheless it is not assumed to be flawless, because limitations will most likely be found with this as with all empirical formulas. It should be borne in mind that this is not offered as an absolutely accurate formula of pure mathematics, but as a formula in practical engineering, to reduce the time for calculations heretofore requiring hours to a few minutes. The formula is

$$Ea = \frac{Eg[20R - r(N + 0.5)^2]}{9r(N + 0.5)^2 + 20R}$$

or in another form,

$$Eg = \frac{9rEa(N + 0.5)^2 + 20REa}{20R - r(N + 0.5)^2}$$

where

N = The number of parallel equal resistances in the circuit (N does not include the resistance of the source of em.f.);

Eg = The external voltage at the source of em.f.;

Ea = The voltage across the last parallel resistance;

R = The resistance in ohms of each parallel resistance;

r = The combined resistance in ohms of both sections of the transmission line, between any pair of parallel resistances.

All the foregoing values are indicated on Fig. 1.

The table gives the various values of a problem involving 50 parallel unequal resistances with unequal line resistance between each pair of parallel resistances. Comparisons are made at different points showing the error in the result obtained from the formula and customary longhand calculation. Beginning at the far end of the line, the equivalent line resistance and parallel resistance is given at every fifth parallel back to the source of power.

To find the voltage Ea at the out end of the line where the voltage at the source of em.f. is known:

$$Ea = \frac{Eg[20R - r(N + 0.5)^2]}{9r(N + 0.5)^2 + 20R}$$

$$= \frac{169.6[(20 \times 43.6) - (0.0355 \times 50.5^2)]}{(9 \times 0.0355 \times 50.5^2) + (20 \times 43.6)} = 79 \textit{ volts}$$

Again to find Eg, the voltage required at the source of em.f., when the pressure at the last parallel resistance is known:

$$Eg = \frac{9rEa(N + 0.5)^2 + 20REa}{20R - r(N + 0.5)^2} =$$

$$\frac{(9 \times 0.0355 \times 80 \times 50.5^2) + (20 \times 43.6 \times 80)}{(20 \times 43.6) - (0.0355 \times 50.5^2)} = 171.9 \textit{ volts}$$

If it is desired to find the voltage $E'g$ at a point in the system at the fifth parallel resistance from Ea, this point is indicated at 45 in Fig. 2. The equivalent line resistance between parallels up to this point is equal to

$$E'g = \frac{9rEa(N + 0.5)^2 + 20REa}{20R - r(N + 0.5)^2} =$$

$$\frac{(9 \times 0.074 \times 80 \times 5.5^2) + (20 \times 44 \times 80)}{(20 \times 44) - (0.074 \times 5.5^2)} = 82.1 \textit{ volts}$$

TABLE GIVING THE VARIOUS VALUES FOR A CIRCUIT OF 50 PARALLEL UNEQUAL RESISTANCES

No. of Parallel Resistances from the Source of Em.F.	r	R	Equivalent Equal r	Equivalent Equal R	E Customary Long Hand Calculation	E by Formula	Error of Formula Per Cent.
50	0.1	80	.....	....	80.0	79	....
49	0.05	40	.....	....	80.1	....	....
48	0.08	60	.....	....	80.3	....	....
47	0.11	20	.....	....	80.6	....	....
46	0.03	20	.....	....	81.5	....	....
45	0.05	30	0.074	44	81.9	82.1	+0.2
44	0.02	10	.....	....	82.6	....	....
43	0.06	90	.....	....	83.1	....	....
42	0.09	40	.....	....	84.6	....	....
41	0.03	50	.....	....	87.0	....	....
40	0.04	50	0.062	44	87.7	86.3	—1.6
39	0.07	20	.....	....	88.8	....	....
38	0.02	80	.....	....	91.1	....	....
37	0.01	80	.....	....	91.8	....	....
36	0.04	40	.....	....	92.1	....	....
35	0.05	100	0.053	47.3	93.6	91.0	—2.7
34	0.03	20	.....	....	95.5	....	....
33	0.07	40	.....	....	96.8	....	....
32	0.02	30	.....	....	99.9	....	....
31	0.03	60	.....	....	100.9	....	....
30	0.06	40	0.050	48.0	102.4	98.0	—4.3
29	0.03	80	.....	....	105.6	....	....
28	0.06	20	.....	....	107.2	....	....
27	0.04	50	.....	....	110.7	....	....
26	0.03	50	.....	....	113.2	....	....
25	0.10	40	0.0488	48.0	115.1	107.5	—6.6
24	0.02	50	.....	....	121.7	.....	....
23	0.04	20	.....	....	123.1	.....	....
22	0.05	30	.....	....	126.1	.....	....
21	0.05	40	.....	....	130.1	.....	....
20	0.02	70	0.0493	46.0	134.2	122.5	—8.7
19	0.01	60	.....	....	135.9	.....	....
18	0.03	50	.....	....	136.8	.....	....
17	0.01	50	.....	....	139.5	.....	....
16	0.01	60	.....	....	140.4	.....	....
15	0.01	30	0.0446	47.7	141.4	130.3	—7.8
14	0.03	40	.....	....	142.4	.....	....
13	0.02	50	.....	....	145.5	.....	....
12	0.01	20	.....	....	147.6	.....	....
11	0.02	30	.....	....	148.7	.....	....
10	0.02	20	0.0413	46.0	151.1	143.7	—4.9
9	0.01	30	.....	....	153.6	.....	....
8	0.005	50	.....	....	154.9	.....	....
7	0.02	30	.....	....	155.6	.....	....
6	0.01	40	.....	....	158.4	.....	....
5	0.01	50	0.0381	44.6	159.8	157.8	—0.6
4	0.02	70	.....	....	161.3	.....	....
3	0.015	10	.....	....	164.2	.....	....
2	0.005	30	.....	....	166.7	.....	....
1	0.01	10	.....	....	167.5	.....	....
Source of em.f	....	..	0.0355	43.6	169.6	171.9	+1.3

against 81.9 volts given in the table for the customary longhand method of calculation, or an error of about 0.2 per cent.

The foregoing applies to any part of the transmission line. For example, the value of $E''g$ at the forty-fifth parallel resistance from Ea is

$$E''g \text{ (45th from } Ea) =$$

$$\frac{(9 \times 0.0381 \times 80 \times 45.5^2) + (20 \times 44.6 \times 80)}{(20 \times 44.6) - (0.0381 \times 45.5^2)} = 157.8 \textit{ volts}$$

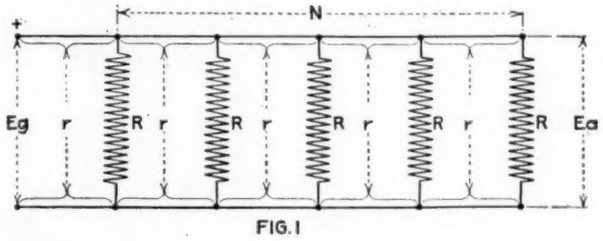


FIG. 1

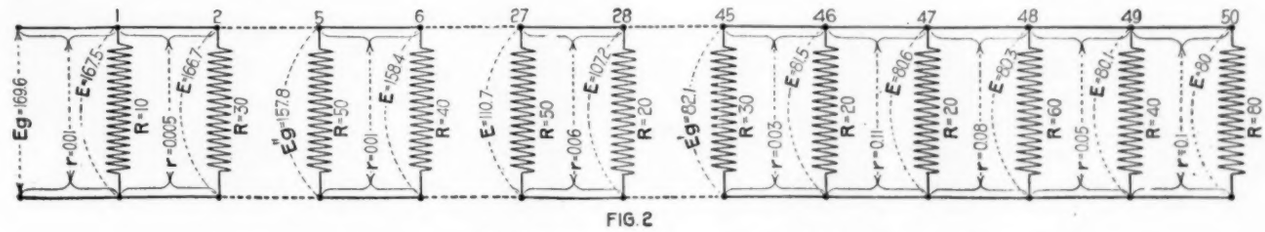


FIG. 2

FIGS. 1 AND 2. CIRCUITS MADE UP OF A NUMBER OF PARALLEL RESISTANCES

$(0.03 + 0.11 + 0.08 + 0.05 + 0.1) \div 5 = 0.074$ ohm. The equivalent parallel resistance equals $(20 + 20 + 60 + 40 + 80) \div 5 = 44$ ohms. Note that the parallel resistance at the point where the voltage $E'g$ is calculated is not included. Then

The values for the foregoing calculations are given at 5 in the table. It will be seen that the longhand calculation gives 159.8 volts for $E''g$ at the forty-fifth parallel resistance from Ea against 157.8 by the formula, an error of 0.6 per cent.

The Gibson V-Notch Flow Meter

The consideration of the V-notch meters in the issue of May 1 has brought to light others not so well known. G. H. Gibson has had issued to him six patents, Nos. 1,048,677, 1,191,415, 1,196,375, 1,202,052, 1,202,053 and reissue 14,206, covering various features and details. Fig. 1 shows one form of construction or means of obtaining a pen motion corresponding to the varying rate of flow through a V-notch or the $^5/_2$ power of the head. The float carries a vertical rod, one side of the upper end symmetrically curved, against which a roller attached to the integrator mechanism is pressed, so that the correct rate of pen movement per unit of float rise can be secured. Two means of resisting the force of the float or bucket are covered, as shown in Figs. 2 and 3. In the former compressed air or pressure fluid in the upper compartment is used to balance the weight of water contained in the bucket (or, as in the other case, the buoyancy of the float), and operate the indicating or recording mechanism. The electric system, as shown in Fig. 3, consists of a float of peculiar shape operating a lever, the end of which makes an electric contact by a slight movement in either direction from a central position. When contact is made, an electric current passes through a small motor operating a screw or worm gear in either direction to again bring the arm back to its central position and at the same time operates the indicator. The bucket or displacement body can be made of such shape that when held in approximately the same position it will exert a force on the resisting member, just described, varying as the rate of flow varies, and the magnitude of this force is indicated and recorded by a mechanism that may be located in any convenient place. There are numerous modifications.

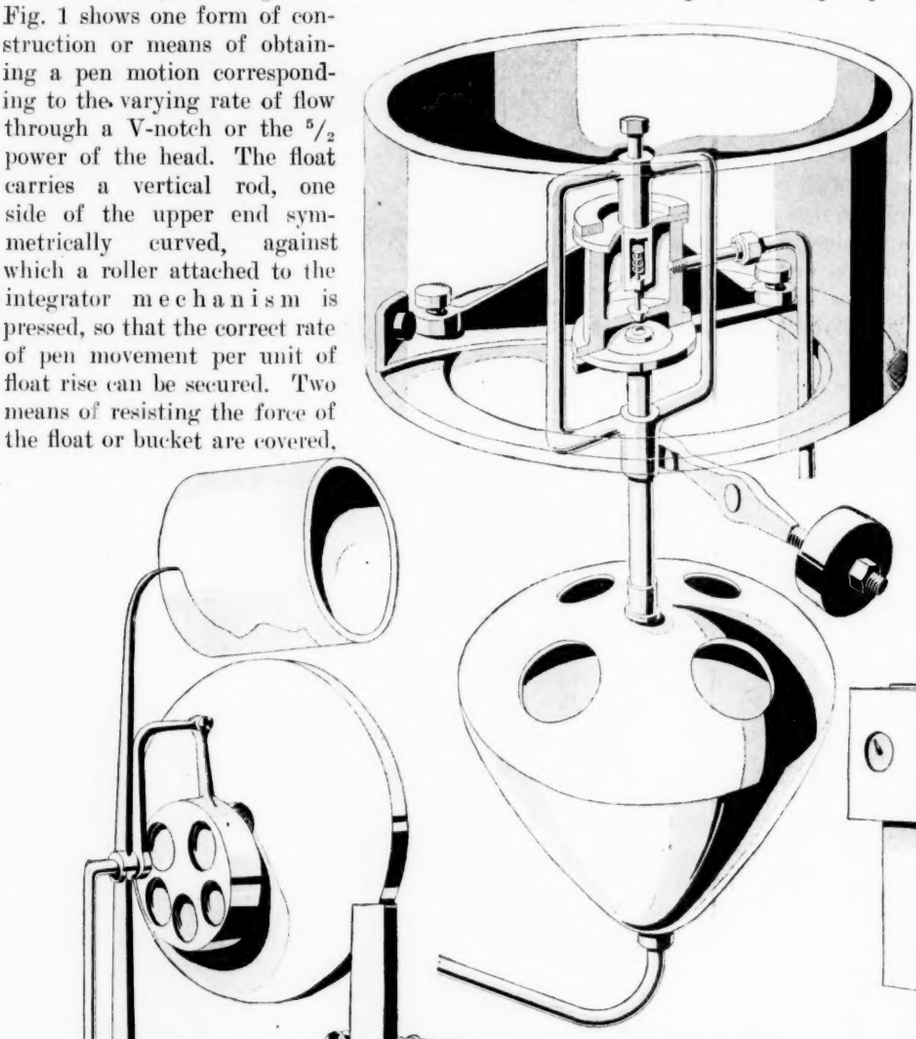


FIG. 2. COMPRESSED AIR AS THE WEIGHING MEDIUM

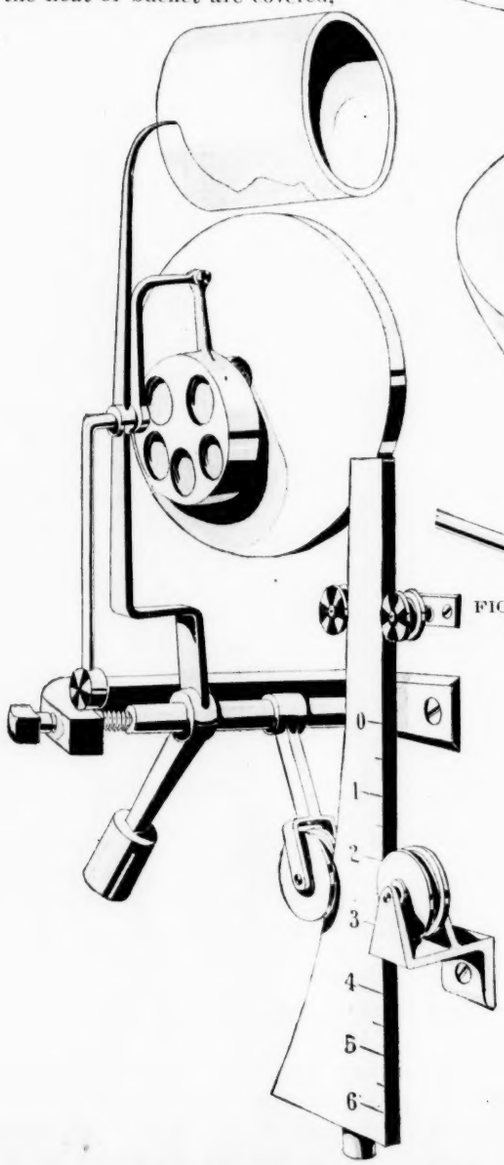


FIG. 1. FLOAT MOTION TRANSLATED BY CURVED ROD

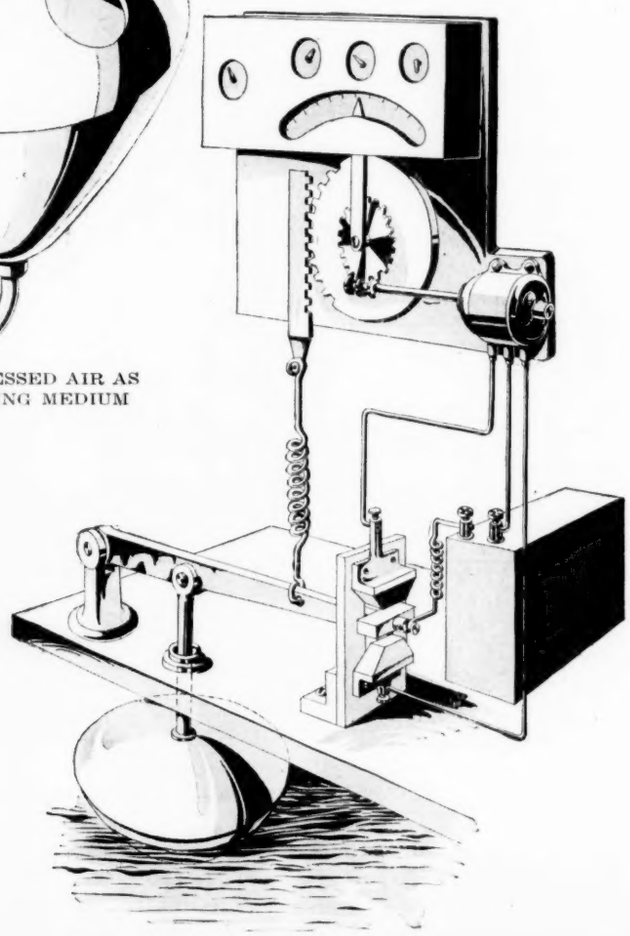


FIG. 3. ELECTRIC DEVICE RESISTING BUOYANCY OF FLOAT

Editorials

Interconnecting Power Systems

The advantages of standardizing our electrical power systems so that one may be tied into another with a minimum of costs is generally conceded. Although considerable has been done in recent years toward standardizing power equipment, the existing conditions are such as to make it impossible to take full advantage of the interchange of power between one system and another. Never was there a greater need for interconnecting the power systems throughout the country than at the present time.

Of paramount importance in any intensified industrial activity is an adequate and reliable source of energy. In normal times the power plants have in general experienced no difficulty in meeting the demands of industrial expansion, but in abnormal periods like the present, it is much more difficult. On account of the impossibility of obtaining power equipment on short-time delivery, power plant extensions cannot be made rapidly; therefore, it becomes a matter of working the existing plants at their maximum output. On the other hand, the price of coal and other materials used in the production of power has increased far beyond that of normal times, and the uncertainty of the delivery of fuel has created a serious problem and made the question of coal economy one of great importance. The prospects of a depletion of the power-plant working forces to supply other needs of the nation tend to increase the seriousness of the power problem.

All the difficulties confronting the power situation call for not only the most efficient operation of the power-plant equipment already installed, but also its utilization to the best advantage. The solution is found in the interconnection of the various power plants so that any surplus capacity of one may be used by some other having need of it. This does not pertain to central stations alone; there are many isolated plants that can be tied on the network with advantage to both parties.

Since the war began, the subject of linking up the various power systems has received no small amount of attention in Europe, especially in England, where the question of fuel economy has become an urgent one. However, this unification of the electrical systems is a problem fraught with many difficulties on account of the promiscuous development of the past, even more so in England than in America. Within the City of London alone there are in operation forty-nine different systems of generation and distribution, including ten frequencies and twenty-four voltages.

In this country the voltages of direct-current systems are well standardized, but a consideration of our alternating-current systems shows a far different condition. This problem would not be so difficult if it were only in voltage that these systems differed, but they differ also in frequency and phase. We have in use at least eleven frequencies, almost innumerable voltages and three different phases. The voltages and phases in general do not offer any serious problem. The voltages can be changed and two-phase converted into three-phase or vice versa by static transformers, and a single-phase load can usually be balanced on a two- or three-phase system. However, in the case of the frequencies some of these are not convertible into the frequency of other existing systems, and those that are changeable require expensive and inefficient machines. When such machines have to be used one of the main advantages of interconnecting power systems is lost, especially at the present time when it is desirable to take care of the country's power needs with the addition of a minimum of equipment.

The government of Japan, seeing the advantage of the unification of power systems, has given considerable attention to this matter and has issued certain regulations that have for their aim the standardization of the nation's power supply, both hydro-electric and otherwise, and its distribution, having learned by experience that droughts may seriously interfere with the regular hydro-electric supply, but that if a high degree of standardization is maintained it is possible to combat the emergencies by interconnecting the various plants.

The Training of Operating Engineers

As previously expressed in these pages, we believe that one of the great compensations to come from this war is the adaptation by the world of the thorough efficiency in industry and state organization so long practiced by Germany and which is the chief thing that makes her the most formidable foe. Because of this, we shall likely see a wide application of vocational training. There is every reason to believe that, despite the elevating tendencies of the classical studies, the aim of education will be more utilitarian than ever before. In many respects this is to be regretted. Even now there is a woeful lack of appreciation of the finer literature and of the graver responsibilities of life, on the part of our young people particularly.

The hours of the American workman are shorter and his pay is greater than those of the workman of countries with which we will be engaged in competition for trade. To successfully compete we must, to offset our higher labor and selling costs, reduce the cost of manufacture to a minimum. Industrially, there is no question that utilitarian education, such, for instance, as the Germans have exacted from those engaged in all branches of industry, not only tends to make better engineers, chemists and works managers, but it gives specific training to nearly all engaged in the industries.

With the United States—the world, in fact—growing and mining raw materials, manufacturing and selling on a more scientific basis than even some of our large manufacturing concerns are now doing, it is certain that no department in a manufacturing establishment will go un-

checked as to its performances. Power may consume but three and a half to four per cent. of the cost of manufacturing the product, but in manufacturing, as in most of our large central power stations, this heretofore neglected percentage will be reduced to the minimum.

It is unfortunate that there are no well-organized methods of training the operating engineer. He is left to his own resources and initiative. There are few places where the city or state is giving any assistance whatever in the training of these men. Some of the larger stations—and most of these are central stations—conduct schools wherein men engaged, not only in the power plant, but in other departments, receive instruction. A young man entering the engineering department of a large manufacturing establishment is indeed fortunate if his chief shows sufficient interest in him to encourage him to study the operation of the different apparatus of the plant. If such a young man ever learns anything at all about depreciation, overhead costs, investment, fixed charges and the other economic factors so important now in the conduct of a large power station, he does it through his own initiative. The public schools and other institutions give him little or no aid. Too many chief engineers know too little of power plant economics.

We are not unmindful of the good work that is being done by the Educational Committee of the National Association of Stationary Engineers. What there is of this work is commendable, but it is inadequate. There does not seem to be a sufficient realization of the needs. We wonder if the officers of the National Association of Stationary Engineers—just to take one of the organizations, the largest—ever considered what a benefit it would be to the operating engineer if the organization afforded him a school from which he might receive instruction, from which he might graduate and from which he could get a recognized diploma—a school of the correspondence class, run at cost for the members. One is of course justified in questioning the use that would be made of such a school if it did exist. The present correspondence schools have certainly tried to make it easy for the engineer to take advantage of the opportunities for study offered by them, the rates being lowered considerably to encourage the men, but there has not been the response that one would look for.

The operating engineer in an industrial plant is just as truly engaged in competition with the corporations that make and sell power as one manufacturer is engaged in competition with another making a like product. It needs no argument to convince one that organization of an engineering character is necessary to give these men an even chance. The central-station industries are organized, and rightly so. The public in many and various ways is told by these interests that the community is best served by centralized power. Let any practice become general enough and the world will believe it. Science itself furnishes many examples of this. Unbiased minds know that the central station alone is not the means of solving the community's power problems, and they know too that the isolated plant is not alone the rightful source from which to serve power for all purposes and in all places. But however good the equipment in an isolated plant, if its management is not intelligent, if it is not directed by a man well trained in the business, that plant cannot hope to compete with purchased power. That sermon has long been preached.

It is indeed too bad that the Institute of Operating Engineers became defunct when it did. At the time it may, perhaps, have aimed too high. It may, perhaps, have not considered the effect of class distinction among its members. But it had one excellent feature, and that was that every engineer, particularly every chief engineer, made or was in duty bound to make a classroom of his plant. Under such a plan the oilers, assistants and firemen are assured of everything that is to be gained by a thorough study of the plant's equipment. The benefit to be gained by the general adoption of such a plan, not only by organizations of operating engineers, but by the men in any particular plant, are too great to justify allowing its practice to fall into disuse.

The young engineer, as well as older inadequately trained men, cannot, of course, hope to find in every community a school or a class publicly conducted for the training of power-plant engineers. The state, however, should interest itself in providing some means greater than now exist, by which men in the mechanical trades may get free a better training in mathematics and physics than is at present afforded.

The sooner the young people of America stop measuring the value of their lives by the pleasures they have had, the better for the nation. This is especially true of young men entering engineering, professionally or otherwise.

Coöperation Between Central and Isolated Plants

Elsewhere in this issue appears an article which discusses some measures for greater coöperation between central stations and isolated plants. Briefly, the proposal is that private plants be tied in with central stations for the purpose of supplying the peak loads of the latter, thus reducing the high cost of supplying such peaks. The authors of the paper point out that a study of the load curves of most central stations shows that the highest load occurs only during a few days each year and only for a few hours each day. This does, as the authors say, increase the investment, though when considering the investment for this purpose, one should also remember that a part of such investment automatically becomes an investment in reserve machines, which are in reserve, not alone for this pinnacle load, but also for breakdowns, repair and inspection of other units in the station. According to the plan as taken up by the authors, during the light-load periods of the private plant, when the load on that plant is only from 5 to 10 per cent. of the maximum, the plant is to buy its current from the central station. As the authors point out, this plan is not altogether new, inasmuch as the Longacre Electric Company, of New York, several years ago planned to do this very thing, but, owing to franchise trouble, was never able to make a start.

Broadly, from an economic standpoint, the present waste in the furnishing of power by both central stations and private power plants should not exist. It is of course true that the problem is not easy of solution, but as there is a loss, and further, as the public must pay this loss, it is the business of the engineer to devise means for eliminating the condition, after which all artificial barriers that prevent the application of the more economical methods should be broken down.

Correspondence

Eliminating the "Kicker"

In nearly all plants where there are three or more engineers, there is almost certain to be at least one man who never finds things right when coming on watch. No matter what effort is put forward, he is bound to find something wrong. Nothing is so discouraging and detrimental to the good fellowship that must exist where good work is to be performed as this continual "nagging." While I do not countenance carelessness, I do not consider an oil cup feeding slow, or a brush sparking slightly as sufficient ground for a complaint.

I was once employed as first assistant in a hotel plant in which the day-watch engineer was a typical kicker. Every morning it was the same: "The oil cups on No. 2 were only half-full when I came on watch," or "the brine pump pit railing had finger marks on it," etc. None of the complaints merited the chief's interest; they only caused a general disagreeable feeling among the men.

WATCH REPORT SLIP

Watch..... Date, ...

Notice. To Relief Engineer—In signing this slip you assume full responsibility for the plant and its condition. If anything is not satisfactory, make an entry to that effect before signing slip.
To Watch Engineer—If there is anything wrong in the plant, make an entry covering the matter, on this slip, before handing to the incoming engineer.
This slip must be dropped in the box provided for that purpose in the presence of both engineers.

Time..... Watch engineer.....

Condition of plant at end of run:

.....

.....

I have looked the plant over, and with the exception of the above entry, I have found everything satisfactory.

Signed.....Relief Engineer.

Notes of watch engineer:

.....

.....

Signed.....

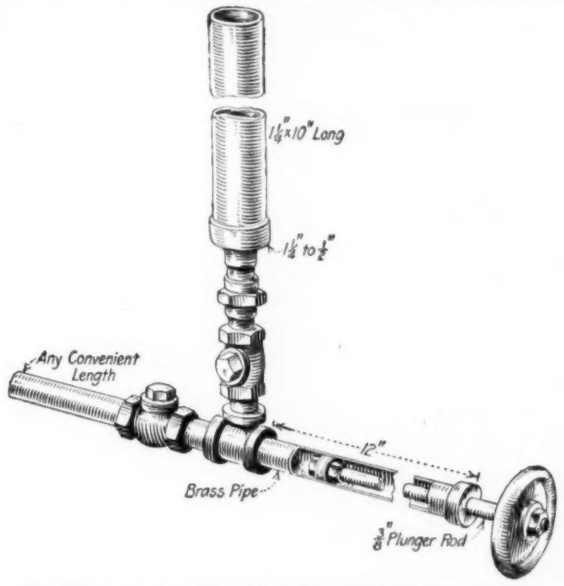
However, we worked up the accompanying report slip, the idea being to make every incoming engineer find out if there was anything wrong or not before he took the plant over, and have it settled before the outgoing man left, as my experience has been that most kicking is done behind the other fellow's back.

Each watch engineer and fireman takes one of the slips upon coming on watch and records such matters as occur during his run that will be likely to affect the man following him. At the end of the run he signs the slip and hands it over to his relief. After the relief has looked the plant over and noted any unusual conditions, he enters any notation of his own on the slip, signs it and drops it into a locked box provided for that purpose, from which it is later removed by the chief. If the relief has any fault to find, he must make it to the outgoing man personally or write it down on the slip, and in either case it allows for adjustment. Once the relief had signed the slip and dropped it in the box, it was up to him. These slips had nothing to do with the plant records, and any statement on them was only in the nature of protection for the men. While at first the idea was resented by the kickers, yet the plan worked out so well that it has become a regular part of the system.

Quincy, Mass. A. D. PALMER.

Forcing Obstructions from Ammonia Trap Lines

The sketch shows a pump that I made for opening the plugged blowoff pipes to our ammonia traps when they became stopped with scale or other matter. One day when I attempted to blow out the oil on the high side of the machine, I found that it was stopped so tightly with scale and rust that the pipe was tight against the air



FORCE PUMP FOR RELIEVING PLUGGED PIPES

pressure of 180 lb. with the valve wide open. I decided to force the scale and rust back into the trap and for this purpose made the pump shown. The ammonia lubricating oil was the liquid pumped into the line against the obstruction. Note that the oil is to be poured into the suction side of the pump, which may be so adjusted as to stand vertical. S. C. CARTY.

Washington, N. C.

Repairing a Commutator

A commutator in which the mica insulation has become pitted or dislodged may be repaired in the following manner: Mix a small portion of French chalk with a little sodium silicate so as to form a thick paste, clean away all loose particles of mica, etc., and apply the paste with a knife or thin flat piece of wood, allowing a few hours to dry.

I have also found this paste to be very useful when repairing rheostats, or remodeling switchboards, as it is a good nonconductor and will harden in a short time.

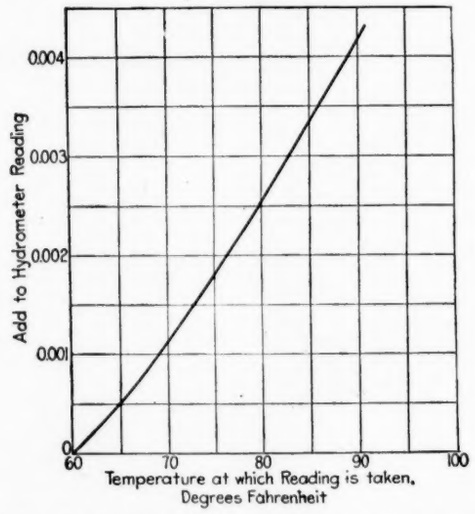
Beaver Dam, Wis. S. W. PALMER.

Testing Boiler-Feed Water

With the present trend toward high boiler ratings and large units, the question of boiler-feed water becomes increasingly important. The quality of feed water, where condensate cannot be used, is a local condition and has to be worked out for each individual case. Commercial scale preventives and softening systems substitute sludge matter for scale-forming impurities in the water. This means that the water in a boiler will become more and more concentrated unless blown down systematically, and tube ruptures and priming troubles will occur.

It appears to be well established locally that when the specific gravity of the water in a vertical water-tube boiler reaches about 1.003, tube ruptures are likely to occur if the boiler is forced much beyond normal rating. This limit may be lower with boilers having inclined water tubes or poorer circulation other things being equal. I would appreciate a discussion by engineers having data on this point.

For the purpose of establishing a systematic blowing-down process in a plant of about 10,000 hp., I employ the following method: Very sensitive hydrometers gradu-



SPECIFIC GRAVITY CORRECTION FACTOR CURVE

ated from 0.995 to 1.005 are used to measure the specific gravity. Samples are taken from small pipe connections to the lower drums. The temperature of the water sample when tested for gravity is very important, as a change of 10 deg. will change the gravity about 0.0012. A curve that is self-explanatory has been worked out and is shown in the illustration. It is of value to avoid the necessity of bringing the samples to standard temperature each time the specific gravity is measured.

Midland, Mich. J. R. BELKNAP.

Why Twist the Pulley?

It has just occurred to me, so I write on the spur of the moment—did you ever propound in your columns the question, why is it that, in forcing a pulley on a shaft, you can gain by twisting the pulley? Very few engineers can give the mechanical explanation of this familiar fact. You might set your young readers guessing on this. SIDNEY A. REEVE.

New York City.

Watch Engineers' Time Schedule

In some of the late copies of *Power* I have seen discussions of "Watch Engineers' Time Schedule," and a brief note of the Australian custom may be of interest. For some eighteen years I have been associated with watch engineers in different places, and it has always been the custom for the oncoming shift to relieve the preceding shift with only a verbal report of conditions aside from the regular official report, which includes all stoppages or alterations for repairs, etc., and the shift foreman passes all orders on from shift to shift, and the leading hands in various places do likewise.

The shifts work eight hours each, midnight to 8 a.m., 8 a.m. to 4 p.m. and 4 p.m. to midnight. Locally, on Saturday nights, one shift finishes and stands off until 8 a.m. Monday. The shift finishing at 8 a.m. Sunday returns to work at 4 p.m. to relieve the day shift, and the day shift comes on at 12 Sunday night for its week of night shift. Thus each shift works day, night and afternoon in regular rotation with every third Sunday off and 16 hours one Sunday.

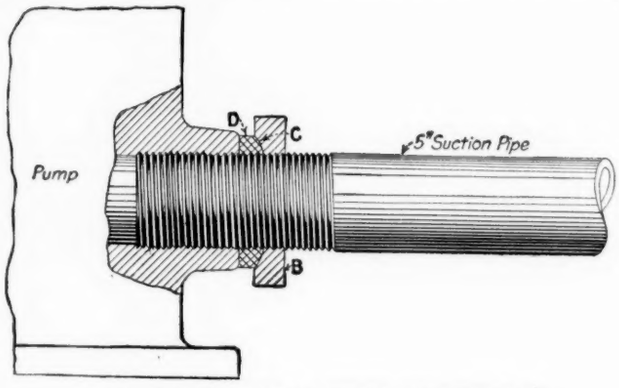
As the various men know all the duties of their positions and work in regular rotation, it seems to me a waste of time for men to work from one hour upward in double banking. If it is necessary, the places must be understaffed or else the men will merely be wasting their time. Australia has the universal eight-hour day, and the men would require overtime rates for that extra hour that can well be cut out.

While we have no really big plants compared with those in the United States, we have plants that require the same continuous working on a smaller scale. This system has been in general use for many years and has had a fair trial, and I see no reason why it should not apply equally well to American plants. H. N. PAIGE.

Queenstown, Tasmania, Australia.

Locknut on a Bad Thread Joint

The illustration shows how I repaired a leaky suction connection to a boiler-feed pump. The threads in the pump body were bad, so I threaded the pipe on the lathe and made a brass collar *B* to fit the pipe, with a bevel or



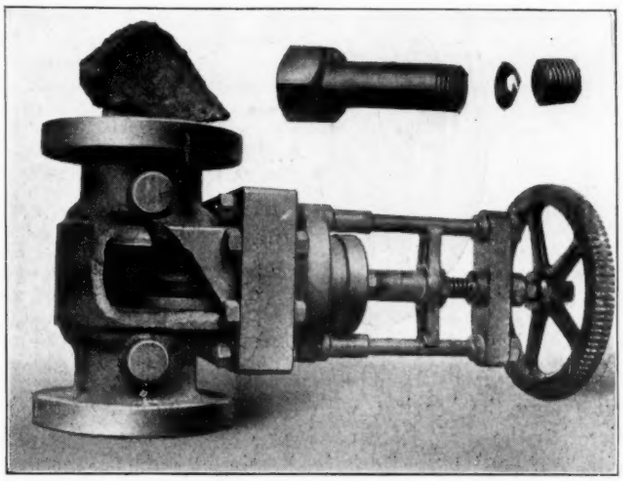
PACKING STOPS LEAK FROM BAD THREAD

countersunk face at *C* to hold a ring of packing *D*. After screwing the pipe in as far as possible, I inserted a ring of packing and tightened the brass collar up against it, making a good tight joint. G. M. PIERCE.

Eriton, Penn.

Wreckage from Water-Hammer

The photographs showing the effect of water in a steam line may interest your readers. A 4-in. gate valve was broken by water-hammer, and the engine was strained and racked all over by water thrown over into the cylinder when a bypass was opened to drain the piping. The 3-in. bolt shown was the corner bolt holding the crank pedestal block to the engine frame. It was made from mild steel



SOME OF THE RESULTS OF WATER IN STEAM PIPE

but somewhat crystallized, which probably caused it to fracture; the middle piece is the thickness or pitch of one thread.

Moral: Shut off the steam at the main before opening drains or trap bypasses to drain waterlogged steam pipes.

Partick, Glasgow, Scotland. W. MACLEAN.

Leather-Belting Specifications

There does not appear to be available any specifications for leather belting that are acceptable alike to the manufacturer and the user. While there are limits defined as regards belt width, they are lacking in variation in thicknesses, and it would seem desirable that the latter should be specified. One maintained to the writer that a variation of 10 per cent. is reasonable, another that $\frac{1}{32}$ in. is a practical standard, while investigation shows that there is a variation much in excess of either.

A common expression used is, "Oak-tanned belt on being bent strongly by hand should show no cracks on the hair or grain side of the belt." I have met men who possess strength enough to crack almost any piece of belt by so bending. It would seem desirable to substitute some other test, such as bending over a suitable wooden block having a definite relation to the thickness of the belt tested. The tensile strength of the belt is not so important as the elasticity—the amount that a belt may be stretched and recover its original length—yet there are no statements covering this feature in any of the specifications I have examined.

That poor belting will be eliminated, where accurate records are kept, on account of its poor showing in economy goes without saying. A discussion of belt specifications should prove valuable for the guidance of all interested. FRANK H. WILLIAMS.

New Haven, Conn.

Burning Oil Out of Boilers

A rather unusual method was used, on board one of our naval cruisers some time ago, for the removal of a stubborn oil deposit on the interior of the tubes of eight water-tube boilers after the ship had completed a two months' cruise at high speed. Considerable oil had found its way into the boilers, and the usual method of boiling out with compound and then blowing down failed to eliminate the oil and grease.

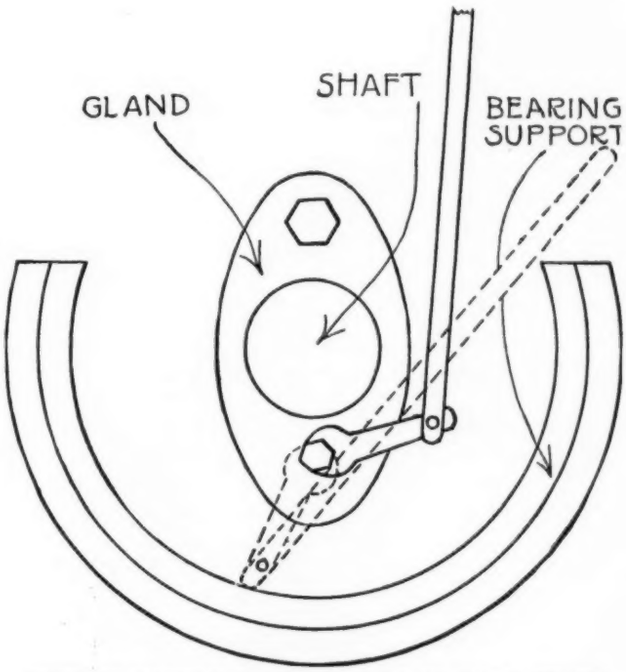
The tubes were then subjected to a baking process, to dry out the deposit. A very light fire was built under each boiler, keeping the draft so regulated that the heat could not injure the tubes. As soon as the oil sediment had dried to a brown powder, it was removed by compressed air blown through each tube at 125 lb. pressure.

Concord, N. H. C. H. WILLEY.

[The foregoing is published "for discussion only." We seriously question the wisdom of the practice suggested.—Editor.]

Wrench for Special Uses

On one turbine we had considerable trouble with the carbon packing rings, so substituted a casing, forming a stuffing-box and gland for soft packing. As there was very little clearance left between the gland and bearing support, extending more than halfway round the under side of the shaft, the gland being longer than the original one, there was no room to get at the bottom nut with a



WRENCH HANDLE JOINTED TO GO IN CLOSE SPACE

wrench more than 3 in. long, so we had to devise some different way to tighten the gland. I cut an "end wrench" off 3 in. from the head and made a handle about 16 in. long, drilled through both and bolted them together, making a swing joint. This prevents burning the fingers and makes a handy little wrench that can be used in many close quarters. M. PAPWORTH.

Cleveland, Ohio.

Starting a New Engine

In reference to H. Hamkens' article, "Steam Engine Troubles," in the issue of Apr. 10, page 490, I would suggest that before starting a new engine it should be first turned at least one full revolution by hand so as to prevent a possible accident due to improper assembling of the various parts. The advisability of this may be illustrated by the following:

In assembling a tandem-compound engine having a connecting-rod of the fork-end type, shown on page 182, Fig. 89, Feb. 6 issue, the bolt passing through the fill piece protruding about two inches from the lower side was secured by two nuts. When the throttle was opened, the engine made one-half revolution and stopped with a heavy thud, as the clearance between the bottom of the crank case and the crank end of the connecting-rod was not sufficient to allow the protruding bolt to pass.

The crank case was gouged to the depth of $\frac{3}{8}$ in. and evidently was cracked, as considerable trouble was experienced later from oil which came no doubt from the leaky crank case, disintegrating the grouting.

A new bolt was necessary and, needless to say, was placed with the head downward. Had the precaution been taken of turning the engine one revolution by hand, this accident would have been averted.

Del Monte, Calif. A. C. McHugh.

Feed-Line Check Was Broken

About 8:30 one morning the fireman's attention was attracted by the low-water alarm on one of the boilers, and thinking that the regulating valve had not lifted, he went up to see. While trying to get water in this boiler, the others started to blow low water. He next thought that the pump pressure was too low and proceeded to raise it, but saw that the pump was running very slowly and that the pressure gage showed 300 lb. At this juncture my attention was called to the matter, and being convinced that the trouble was in the main feed pipe leading to the boilers, we made all haste to get the inspirators to work.

While this was being done, I took the cover off the 4-in. check valve on the main feed line and found the hinge pin broken and the disk tight up against the discharge side of the valve, propped up by the hinge so that practically no water could pass. I took it out and replaced the cover and got water into the boilers all right. Provision was made so that in case of a similar happening at some future time, the faulty check valve would not be the temporary boss of the plant.

Stratford, Ont., Canada. H. T. Westwood.

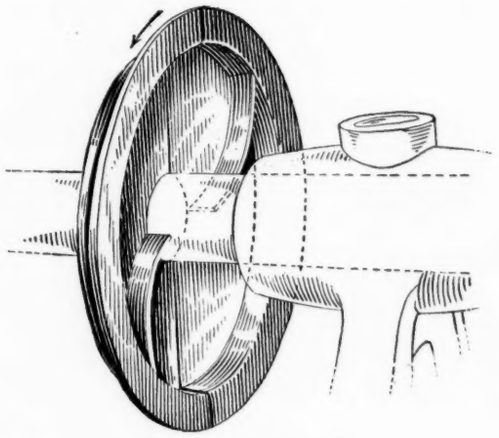
Using Gaskets Over Again

Speaking of manhole gaskets being re-used, I have saved twenty this year by re-using them. After taking out a manhole plate, I clean off the incrustation, etc., and lightly hammer down the outside edges of the gaskets which protrude, doing the same with the protruding inside edges. Then graphite is applied and the gaskets are replaced. I have used some gaskets eight times and they still hold. I have never noticed even a slight leak with any of these re-used gaskets. V. O. Safranck.

Fort Bayard, N. M.

Shaft Oil Shield

The accompanying illustration shows a method that can be used to prevent oil from creeping along a shaft and getting upon belts and pulleys. The disk should be



SHAFT OIL GUARD

put facing the bearing, with the wings pointing in the direction the shaft is to revolve so that any creeping oil will be forced back into the bearing by the slight air pressure created by the wings. The size of disk and the number of the wings can be determined to suit any speed and diameter of shaft. Henry J. Braje.

Winfield, L. I.

Pump Exhausting Into Suction

In answer to J. C. Hawkins' inquiry, in the issue of May 15, page 672, regarding a pump exhausting into its own suction line, I will say that I have a 12 x 7 x 12 pump operating under somewhat similar conditions. It has a 4-in. suction about 400 ft. long; 8-ft. lift; discharge, 50-ft. head; temperature of suction, 60 to 80 deg.; discharge, 120 to 160 deg.; exhaust pressure, $\frac{1}{2}$ to $2\frac{1}{2}$ lb. This pump is used to supply hot water for the water softener, and extra exhaust steam is supplied from other units. The pump must work freely and not pause at the end of the stroke, in order to avoid a break in the suction.

With a tight suction and steady water-supply, no trouble is experienced with operation. Steam is discharged through small perforations to give an even distribution of steam to the incoming water. With its own exhaust only, the pump will run with quite a vacuum. E. G. Hoppe.

Cairo, Ill.

Difficulty in Aligning an Engine

In the issue of May 8, page 638, Mr. McGavin "sees difficulty in aligning an engine," using strips of tin with small holes in the centers.

Using tin centers is quicker and more accurate than calipering a line. Of course the holes in the tin must be larger than the line so that it will not touch. The line will not be put anywhere but directly through the center by anyone who knows what he is trying to do.

Ninety Six, S. C. J. B. Walker.

Inquiries of General Interest

Internal vs. External Pressure on Tubes—Will a steel cylindrical flue or tube offer greater resistance to internal or external pressure? E. L. L.

Cylindrical flues or tubes made of steel offer greater resistance to internal fluid pressure than to external, or collapsing, pressure.

Lower Pressure Requires Larger Safety Valve—If two boilers are of the same dimensions and settings, but one is to carry 50 lb. pressure and the other 150 lb., would one require a larger safety valve than the other? S. W.

Having the same size of grate and burning the same amount of coal per square foot of grate per hour, there would be a larger volume of steam generated per second and the velocity discharged through the safety valve would be lower for steam at the lower pressure. Hence a larger safety valve would be required for escape of surplus steam generated in the boiler that is to carry the lower pressure.

Horsepower Constant—What is the horsepower constant for an engine and how is it found? D. R. B.

The horsepower constant for an engine is the number of horsepower developed per pound of mean effective pressure. In figuring a number of indicator diagrams from one engine running at constant speed, it is most convenient to compute first the horsepower developed per pound of mean effective pressure and multiply this "horsepower constant" by the mean effective pressure of each diagram to find the horsepower represented by that diagram. The horsepower constant is found by multiplying the piston area in square inches by the piston speed in feet per minute and dividing by 33,000.

Objections to Very Cold Water Supply for Economizer—Why is it objectionable to supply an economizer with water colder than about 70 deg. F.? C. M.

The lower the temperature of the cold water supplied, the greater the inequality of expansion and contraction tending to rupture the sections and disturb the joints of the economizer. Greater objection, however, is that the colder the surfaces the greater the amount of water condensed out of the products of combustion and deposited on the heating surfaces, for this, combining with soot carried along by the flue gases, forms a tough, nonconducting coating that impairs the efficiency of the heating surfaces and is difficult to remove; with sulphurous coals it may also set up corrosion.

Collapsing Pressures Resisted by Boiler Tubes—What is the formula for the collapsing pressures resisted by boiler tubes? F. M.

Theoretical formulas for the stresses in cylinders subjected to external pressure are of little value, since such cylinders will collapse before the compressive strength of the material is reached. Extensive tests made on boiler tubes of thicknesses between 0.02 and 0.06 of the diameter, covering all common diameters and thicknesses, and where the length is over 6 diameters, appear to establish the empirical formulas:

$$\text{For cold-drawn seamless steel, } p = 1{,}000{,}000\left(\frac{t}{d}\right)^2$$

$$\text{For lap-welded steel, } p = 1{,}250{,}000\left(\frac{t}{d}\right)^2$$

in which p = collapsing pressure in pounds per square inch, t = thickness in inches, and d = external diameter in inches.

Practical Capacity of 22-In. Double Leather Belt—What number of horsepower is it practicable to transmit with a 22-in. double-thick leather belt, running over a 96-in. diameter cast-iron pulley making 267 r.p.m.? F. A. C.

A good leather belt may be depended on for transmitting 1 hp. per in. of width of single belt and 1.8 hp. per in. of width of double belt without undue distress of the material, when running over a 30-in. diameter iron pulley at 100 r.p.m., which would be about 785 ft. per min. Hence a 22-in. double belt running over a 96-in. diameter iron pulley making 267 r.p.m. should be suitable for transmitting

$$\frac{267}{100} \times \frac{96}{30} \times 1.8 \times 22 = 338.3 \text{ hp.}$$

Boiler Joints with Equal Width Cover Plates—In a butt and double-strap joint, what are the advantages and disadvantages of making both straps of the same width? W. R.

When the inside and outside cover plates are of different widths, there is a lack of symmetry and some bending tendency to distortion of the cylindrical form. Having the cover plates of equal thickness and width, all the rivets are in double shear and the hoop tension on the shell brings a central load on the rivets. The chief advantage consists in removing the uncertainty of strength, due to curvature, of a wide uncalked inside cover plate. The principal disadvantages are that the efficiency is low and the long reaches between the rivets in the outer row are difficult to calk unless the outer cover plate is very heavy.

Boiler-Pitting Trouble—One of our boilers shows signs of pitting. How can the trouble be stopped? H. H. W.

The boiler should be insulated from all electrical currents, as the pitting may be an electrolysis induced by local power or lighting currents or may even be produced by house battery currents that are grounded to the boiler or some of its connections. Destructive electric currents also may result from the discharge of steam at a high velocity such as from leaks in joints discharging from high pressures into the atmosphere. An acid feed water is productive of pitting and hastens electrolytic action. If the water gives an acid reaction, turning blue litmus paper red, it should be neutralized by dosing with an alkali like soda ash. Pitting action of feed waters that are only slightly acid can be checked, and sometimes entirely prevented, by a lime wash over the interior of the boiler or by adding enough lime to the feed water to secure a very thin coating.

Rating of Alternators—How may the kilowatt rating of an alternating-current generator be calculated? The data given on the name-plate are three-phase, 600 volts, 602 amp., 500 kw., field exciter 125 volts. I have tried the rule for finding the kilowatt rating of direct-current machine, but it does not work out. A. R. B.

There is one element lacking in the name-plate data given; namely, the power factor on which the kilowatt rating is based. The value 0.80 was generally used for rating alternators in kilowatts before these machines were rated in kilovolt-amperes, as they are at the present time. From the following, 0.80 will be found to be the correct value for the power factor. The kilowatt rating of a three-phase circuit or machine may be found by the formula,

$$\text{Kw.} = \frac{\text{EI} \times \text{P.F.} \times 1.732}{1000}$$

where Kw. = the rating in kilowatts, E = the volts per phase, I = the current per terminal, and P.F. = the power factor. Hence in this problem,

$$\text{Kw.} = \frac{600 \times 602 \times 0.80 \times 1.732}{1000} = 500.5 \text{ kw.}$$

This value checks with that given on the name-plate.

Correct Welding Flame—What is the correct flame for welding boiler plates? B. E. R.

For successful welding the flame must be neutral, or nearly so with a small excess of acetylene. This is the condition when the inner flame is blue-white with a smooth outline and a rounded point. The outer flame will be brush-like and have a faintly luminous pink color. If there is too much acetylene, the central flame will be pointed and ragged and the flame as a whole will be carborizing; that is, will add carbon to the steel and make it crystalline, hard and brittle. If too much oxygen is used, the central flame will be short, with a point that is too blunt and of dark-blue color. The oxidizing flame will burn out some of the carbon in the steel and thus make it weak and spongy. The oxidizing flame also "burns" the metal, converting it into iron oxide, or rust. An excess of sparks indicates burning of the metal. The flame is likely to change, so that setting it neutral at the start does not insure that it will stay so. If in doubt, slightly increase the acetylene. If the blue cone changes color and lengthens, the flame was oxidizing; if it shortens or the central cone goes out entirely with the enveloping flame long and wide, then the flame was carborizing. Always turn on and ignite the acetylene first, and turn off the oxygen first.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Coöperation Between Central Stations and Private Power Plants*

By Percival R. Moses and W F. Schaller†

SYNOPSIS—Shows typical light- and power-load curves of the Commonwealth Edison Co., Chicago. Tells of the relations of load demands of various customers on required installed capacity in the power station. Discusses the effect of peak loads upon fixed charges. Proposes use of private plants by central stations for supplying power for peak on the latter, thus reducing the production cost on peak loads, opening up a way toward the economic solution of the power problem.

To show what part of the work can best be done by the private power plant and when the service can best be given by the public-utility plant, it is necessary first to understand the condition in each type of plant. The important characteristics to be considered in connection with the study of the central-station or public-utility plant are, first, the load conditions existing in typical central stations, and second, the effect of these load conditions on the cost of supplying electricity, this cost being divided into operating cost, which varies substantially in proportion to the quantity of electricity supplied, and operating cost (overhead expense), which does not so vary. Typical light- and power-load curves for different seasons showing Chicago conditions are given in Figs. 1 to 4 by the courtesy of the Commonwealth Edison Co. The typical characteristics of the light and power load, exclusive of the railroad load, may be summarized as showing a lightly loaded period during the early morning hours, from 20 to 25 per cent. of the maximum load, an average of from 60 to 70 per cent. of the maximum load during the day, up to the period when the lights go on, and then a peak having its pinnacle between 5 and 6 at night in the winter months, usually in December, this peak dropping more or less gradually until 10 p.m., when it rapidly falls off. This is the characteristic of the winter and spring loads. During the summer and fall there is little peak, because of the longer days, but sudden peaks are likely to occur due to a sudden darkening of the sky because of a heavy thunder storm. A characteristic of both winter and summer loads is the drop at the noon hour. The load curves of the Commonwealth Edison Co. show also the variation in demand of the electric railway system, which has two peaks, morning and afternoon, the latter being practically superimposed on the lighting-load peak, although there is a slight diversity factor. Because, however, of this practical super-position of the afternoon peaks, the presence of the street-railway load will not materially affect the discussion which follows:

MUST CARE FOR MAXIMUM DEMAND

These load curves are similar to those in other cities, as Fig. 5, showing curves of a lighting company having a large amusement-park load, the differences being in the degree of difference between peak and average due to greater or less development of day load and after peak (theater and restaurant) demand. The effects of this load are quite important. In fact, they form theoretically the whole basis for the varying rates charged for electric service. The word theoretically is used advisedly, because practically the rates are based on what can be obtained in competition with private plants. Because of the impossibility of economically storing electricity to take care of the peak loads occurring in the winter months, it is necessary for the public utility to provide sufficient generating-plant capacity to take care of this maximum demand with spare units, sufficient feeder capacity to transmit this maximum demand to the substation, sufficient substation capacity to care for the maximum demand of the particular district it supplies or its share of the total supply, and sufficient conductor capacity to carry the low-pressure current to the customer. The curves show the total demand by the electric system; but the sum of the maximum demand by the various substations is in excess of the maximum peak shown at the generating station. In the same way each customer has his individual load curve with a peak, and the sum of the peaks of the customer's individual demands is far in excess of the peak at the generating station and considerably in excess of the peak at the substation. These facts must be comprehended fully to recognize the full value of the load curve in connection with the problem of determining the cost of supplying consumers. The most complete investigation of which we have published record was one made by Gear, of Chicago, for the Commonwealth Edison Co. It is not necessary to republish the tables in Mr. Gear's paper, but it is sufficient to note that a group of 128 residence consumers—that is, apartment consumers—used (on the average) a maximum of 0.44 kw. apiece. Hence if all their maximum amounts had been used at the same time they would have required 57 kw. Actually the maximum required by the group was 17.2 kw. The diversity factor is 3.35.

GENERATING CAPACITY FOR SMALL CONSUMER

In commercial lighting, that is in stores, the maxima more nearly coincide, and in this case where the sum of the consumers' maxima would have been 48 kw., the actual maximum was 33, and the diversity factor 1.46. The maxima of the various districts do not coincide, so there is a diversity factor between the districts. Briefly, it was found that for every kilowatt of maximum demand by a residence consumer less than one-fifth the capacity had to be provided in the generating station. For commercial lighting a little over one-half of the maximum demand had to be provided for, and for large users approximately three-quarters of the maximum demand had to be provided for, because in this case the diversity factor is very low, most of the maximum demand coming at the same period. The converse of the proposition also is true. If we have in the generating station a capacity of, say, 200,000 kw., it will be sufficient to supply nearly 1,000,000 kw. of maximum-demand residence-lighting consumers, or 300,000 kw. of maximum demand by large users.

While on the subject it seems advisable to point out that the term "maximum demand" does not mean connected load. For example, the average connected load in the residence consumers discussed was 0.68 kw., whereas the maximum demand per consumer was only 0.44 kw. To see the effect of this diversity factor on the investment, follow out a few typical examples:

GENERATING CAPACITY FOR LARGE CONSUMER

The first one may be a large store building having a load curve similar to Fig. 6. The maximum demand in this case is 500 kw. The meter and service connections will have to be big enough for the full demand of 500 kw. In determining the size of the main and the feeder from the substation to supply the district in which this building is located, the demand of the building will be taken at 85 per cent. of 500 kw., or 425 kw., and the substation which takes care of all the district around it will need an allowance of only 375 kw. That is, this would be the case if it were not for the losses in the transforming and distribution system. Actually about the same capacity will have to be provided in the substation as the maximum demand of the large consumer. The generating station supplying all the substations will have to have available about 90 per cent. of the 500, or 450 kw. of capacity. About the same capacity would have to be provided in the transmission system between the generating station and the substation. If this consumer had been a residence consumer, a meter would still have had to be provided for his maximum demand, but if he was a resident consumer in an apartment house containing fifty or a hundred apartments, the feeder supplying the building from the main in the street would have been only one-third as large as the sum of the individual maximum demands would require, and only sufficient capacity in the substation would be provided for about one-fourth of such sum and slightly less than this in the generating station. This follows from the fact that small consumers do not use their greatest quantity of current at the same time. The most careful investigation shows that

---

Abstract of a paper before joint meeting of the Boston Sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, Wentworth Institute, Apr. 5.

†Consulting engineers, New York City.

only about 25 per cent. of the sum of the maximum demands of residence consumers need be provided for in the generating station.

By studying the load curve of the central station, it will be apparent that the highest load, the peak, occurs only during a few days in the year and only for an hour or so in each of these days. The late Henry G. Stott, in a discussion of I. E. Moultrop's paper on "Modern Central Station Design," made this statement: "Fifty per cent. of the machinery in a lighting plant operates only 300 hours per annum, so that it becomes most important to keep down the first cost; for assuming that a plant cost $125 per kw. capacity, then the interest and depreciation charges upon the portion of it used for the peak load would amount to 5.2c. per kw.-hr., or

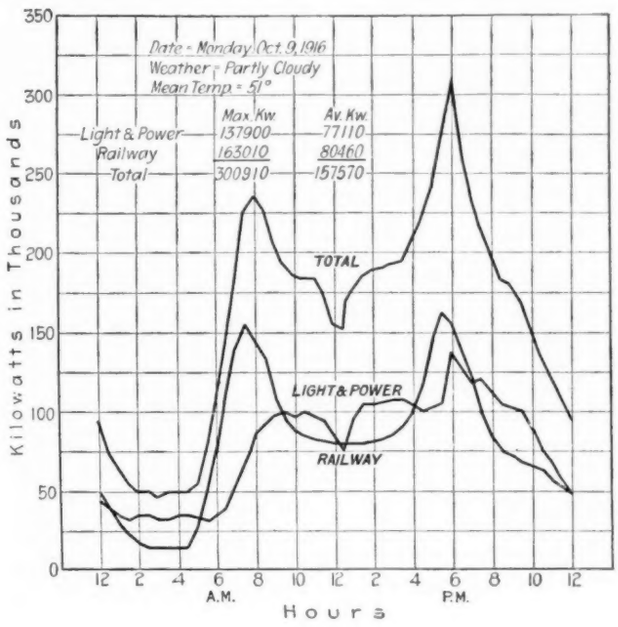


FIG. 1

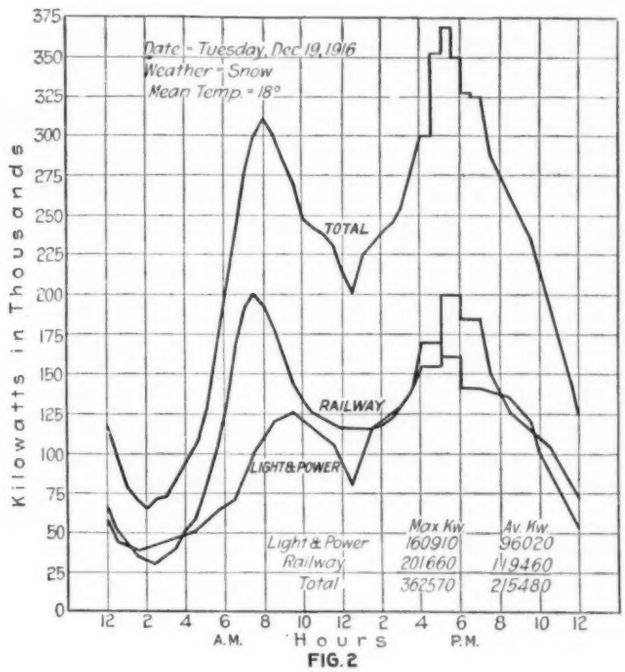


FIG. 2

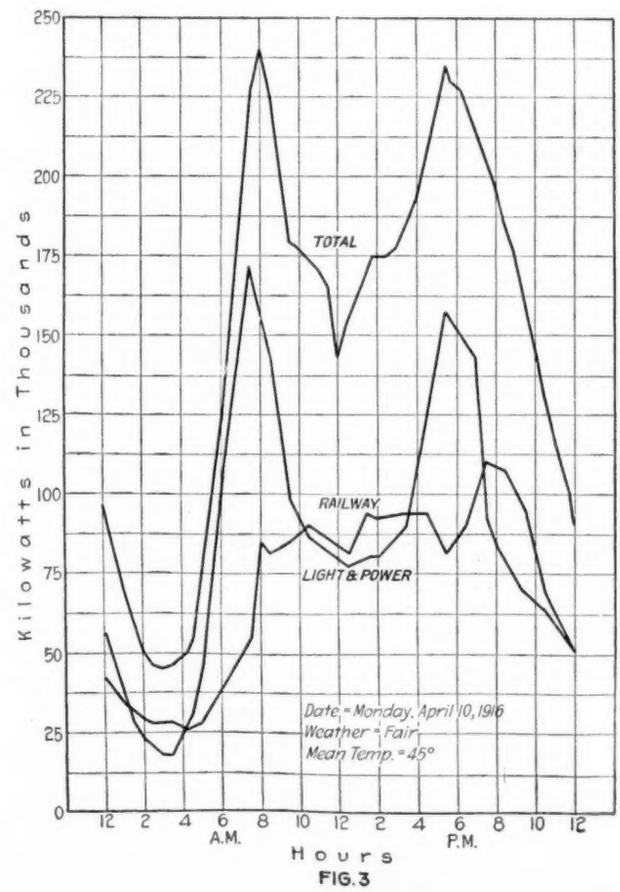


FIG. 3

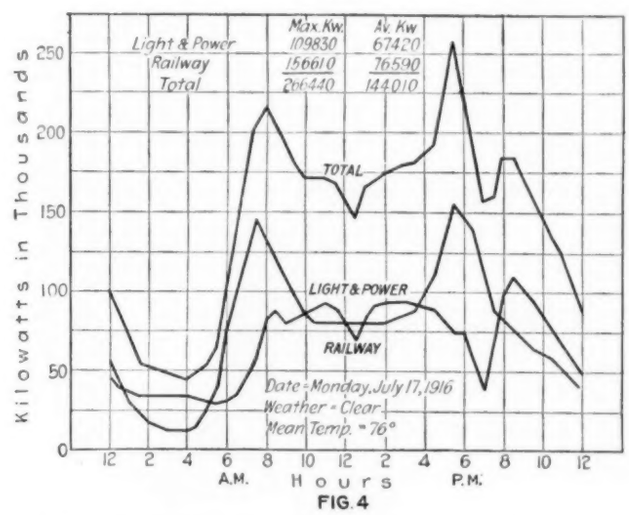


FIG. 4

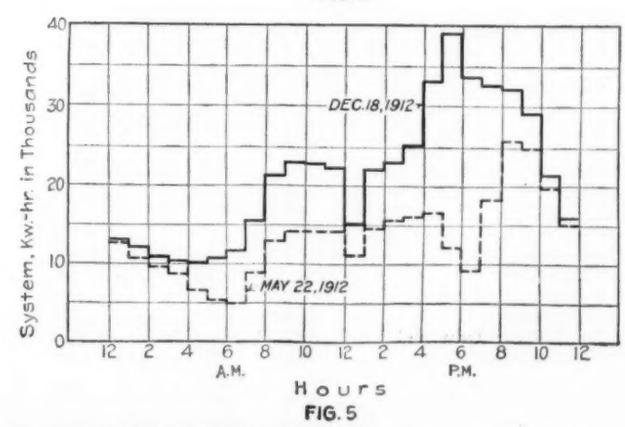


FIG. 5

FIGS. 1 TO 5. TYPICAL SEASON LOAD CURVES OF CENTRAL STATIONS

Fig. 1—Load Curve, October Day, Commonwealth Edison Co. Fig. 2—Spring Day Load Curve, Commonwealth Edison Co. Fig. 3—Winter Day Load Curve, Commonwealth Edison Co. Fig. 4—Load Curve, July Day, Commonwealth Edison Co. Fig. 5—Load Curves of Lighting Co., Including Amusement Park Load

probably five times as much as the operating cost." This statement is quoted to show the small number of hours in which the peak load occurs. It is not quoted in connection with the estimate of effect on cost of current. The $125 per kw. referred to by Mr. Stott represented at that time in his mind approximately the cost of the generating station with its building, land and equipment, and he was only considering the question of the installation of a more efficient piece of apparatus. In this case, of course, the effect of any improved efficiency would be limited to the operating cost, because if the highly efficient machine was only operating 300 hours a year, it is evident that these 300 hours would have to bear all the burden of any increased fixed charges due to the greater expense of the more efficient piece of apparatus. The converse is also true. Any expense which is made necessary merely to supply these 300 hours of peak load should under any proper system of bookkeeping be charged with the interest, depreciation and other fixed charges arising from the investment. As will be evident from the foregoing discussion, the investment necessary to supply this peak is not confined to the generating station, but extends in increasing proportion to

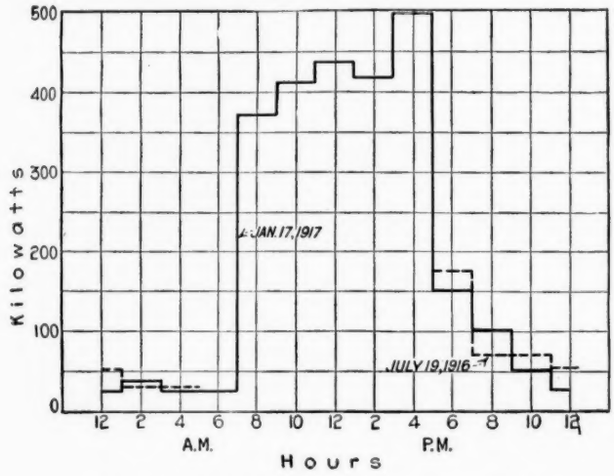


FIG. 6. DEPARTMENT STORE LOAD CURVE

the substation, the feeder and main system and the service and metering connection. In other words, if one-half of the total investment in generating plant, transmission system, substation, feeders, mains and service connections and meters is made necessary to supply the peak load lasting 300 hours during a year, the cost of supplying this peak load is the sum of the operating cost and a due proportion of the overhead charges and one-half of the total fixed charges. These fixed charges would include interest on the total investment, rental of subways, renewal and contingency reserve. Probably the larger portion of the taxes would also have to be included under the fixed charges, divisible as stated. These fixed charges would ordinarily amount to more than the total operating expenses. In one large company, to give a concrete example, the operating expenses per kilowatt-hour delivered to the consumer were 1.96c. The fixed charges as enumerated above were approximately 2.5c. per kw.-hr. The total of fixed charges were about $10,000,000 and the operating expenses about $8,000,000. The total number of kilowatt-hours delivered to consumers was over 400,000,000. If we call the peak of the load that over 70 per cent. of the maximum and we assume that this peak was delivered for 400 hours a year, the maximum load being 210,000 kw., it will be found that 25,000,000 kw.-hr., or one-sixteenth of the total amount delivered to consumers, would equitably have to bear 30 per cent. of the fixed charges, and in the case discussed this would amount to 12c. per kw.-hr., which of course would be in addition to the operating expenses.

Carrying the discussion further, it will be remembered that one kilowatt of the peak at the station was required for each kilowatt of the large user's demand, so that properly speaking, the large user costs the public utility 12c. per kilowatt-hour for the peak load required by him. On the other hand, the residence consumer, who requires only ¼ kw. for every kilowatt of maximum demand in his residence, costs the public utility about 3c. per kilowatt of maximum demand. The commercial consumer at retail quantities would come in somewhere between the two. This is interesting in connection with the claim so frequently advanced that the large consumer is less costly to supply than the small consumer. The purpose of this discussion is to point out the high cost of supplying the peak load from a centralized plant. To make the point still more apparent, it is clear that if some way can be found of supplying this peak load without involving the public utility in the expense of installing large generating units, extra transmission system, extra substation capacity, extra feeder and main capacity, the balance of the business is very much more profitable, as it would mean utilizing the capital invested at a much more steady rate for a much longer period per year. In other words, it would mean a very much better load factor. The curves, Fig. 7, show the fixed charges for different amounts of total cost (not generating-station cost) of public-utility systems. At $500 per kilowatt of maximum demand it will be apparent, from these curves, that all that part of the investment which is not used over 30 per cent. of the 8760 hours in a year, costs over 2c. per kw.-hr., or more than the total production and delivery costs. With $300 investment per kilowatt of maximum demand, any part used less than 18 per cent. costs over 2c. per kw.-hr. and part used less than 25 per cent. costs over 1½c. per kw.-hr. for fixed charges only. Ten per cent. has been used for interest and depreciation in these curves as representing a fair average value for large cities. In smaller and more isolated communities where 7 per cent. or more must be paid for money, this figure would have to be increased.

In the private power plant the peak duration in a number of typical buildings is as follows:

	Prince George Hotel	Bonwit-Teller Store	Columbia Trust Office Bldg.
Amperes, maximum	1,600	2,500	850
No. of hours above 80 per cent. max.	129	489	1,417
No. of hours between 60 and 80 per cent. max.	1,645	1,820	1,253
No. of hours above 60 per cent. max.	1,774	2,304	2,670
No. of hours below 60 per cent. max.	6,986	6,456	6,090

So far we have merely discussed the effect of the peak on the fixed charges, and this is in reality the important factor, for it is questionable whether there is any material effect on the operating expense. With the large units in use today, taking care of the peak load merely means starting one or more of the large units and running them during the period of the peak and operating the boilers at high overload. This of course involves extra investment, but this has been

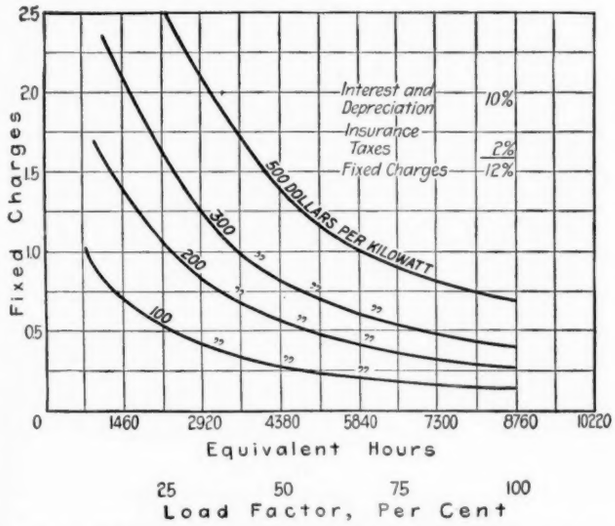


FIG. 7. FIXED CHARGES 5 CENTS PER KW.-HR. FOR DIFFERENT TOTAL COSTS AND LOAD FACTORS

taken care of under the fixed charges. It involves extra labor, but as the output is correspondingly increased, the efficiency during the peak-load period is no lower than the efficiency during the rest of the day.

In general, it is usually conceded that the important operating expenses vary in proportion to the kilowatt-hours delivered, and while there may be small differences in the cost of producing a kilowatt-hour, depending on the character and period of the load, for the purpose of this discussion it will be considered a constant. It will be apparent from the foregoing discussion that the use of a centralized system for supplying peak loads of comparatively small duration is an extremely expensive method, and if some other method could be substituted involving much lower initial investment, good results should follow.

In private power plants, however, the investment to supply a kilowatt of peak load is quite different from the investment required in a public-utility plant, for the investment is

substantially restricted to the power plant. There are no transmission lines, no substations in buildings, no underground network. The dynamo connections to the switchboard may be considered as the service connections from the mains to the building, and there should be the same amount of metering done as there would be in the case of the public utility. In eight cases out of ten in cities there is no expense for building or land to be considered, the space occupied by the private plant being space left vacant in the construction of the building. In out-of-town plants and in special buildings such as newspaper buildings and buildings located on particularly good corners, additional space must be provided and this is a proper charge against the peak-load cost as well as against the main-load cost. Usually there are no extra taxes, legal expenses or insurance, because of the additional plant capacity required to supply the peak. In general, the peak in a private plant means investment in generating

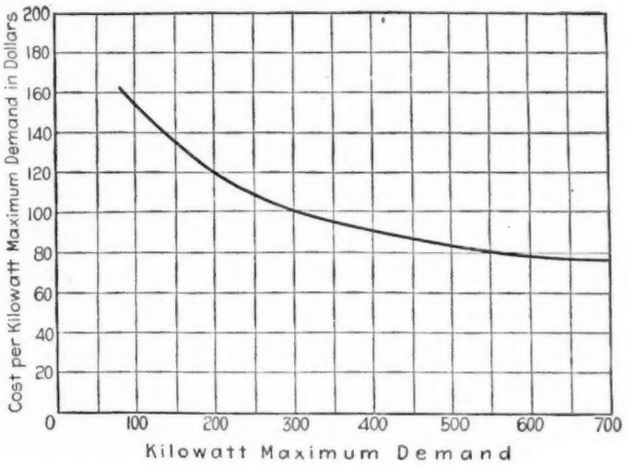


FIG. 8. COSTS OF SOME ISOLATED PLANTS

equipment, switchboard and connections always, sometimes in boiler plant and stack. The question whether additional investment is required in a boiler plant and stack depends upon whether the maximum demand for low-pressure steam for heating, boiling, drying or other purposes is greater than the maximum demand for high-pressure steam required to supply the electric engine. If the maximum demand for low-pressure steam is greater than the maximum demand for high-pressure steam, it will usually be found that no additional investment is required for boiler plant or stack, because of the peak load. With the advent of high-efficiency electric lighting, city buildings, except a few loft buildings and others largely protected by adjoining structures in which a large amount of power is used, need their maximum boiler capacity for heating, not for their electric load. We have gone over the figures from approximately 100 private power plants designed by us during the past twenty years, and in not over 25 has the boiler capacity been affected by the electric load. The cost of providing for peak loads in private power plants will therefore be found to vary between $60 and $100 per kw. of demand. On a basis of 400 hours' use per year, allowing 13 per cent. fixed charges, the cost per kilowatt-hour is between 1.95c. and 3.3c. This compares with 12c. on the same basis of use of the peak with the public-utility plant. It would appear then that the public-utility plant would save between 8 and 10c. per kw.-hr. on its winter peak if it could arrange for the supply of this peak by localized private plants. Fig. 8 shows total costs of a few typical private plants, and Fig. 9 shows fixed charges for different load factors. It will be noted that such part of the investment as is used 25 per cent. of the time costs, in fixed charges less than 0.5c. per kw.-hr. or from one-fourth to one-sixth the cost in the public-utility plant.

What is there in the use of centralized power to counterbalance the saving made in fixed charges? Evidently the only offset is operating cost. The public-utility plant may have a cost of manufacturing electricity of between $^{45}/_{100}$ and $^{50}/_{100}$ of a cent per kilowatt-hour. Allowing for losses, this amounts to between $\frac{7}{10}$c. and $\frac{8}{10}$c. per kw.-hr. delivered to the consumer. The usual cost of manufacturing electricity in a private power plant, exclusive of fixed charges, is from $^{75}/_{100}$c. to 2c., depending on the size of the plant, location, etc.; but this figure includes the entire cost. Of this cost coal is ordinarily from 40 to 60 per cent. and the balance is for labor, supplies and incidentals.

It has been pointed out that the peak load occurs during the colder months, and it is during this time that the exhaust steam can be most fully utilized. If the exhaust steam can be 80 per cent. utilized, it will be evident that the production cost of the power during the peak-load period in a private plant may be equal to or less than the cost of power from the central plant delivered in the consumer's premises, the cost in this case including only the actual production expenses. The fixed charges have already been discussed.

If the private power plants were to be used as adjuncts to the central stations for supplying the peak loads and the exhaust steam could be largely utilized for supplying heat to adjoining buildings, as will usually be found to be quite possible, the production cost of the peak-load power would be still less than the cost just discussed because this cost would be purely a marginal one. It would merely mean operating the plant with the spare unit at full capacity for a few hours. This will not require additional labor. The only cost of the peak-load power will be the cost of such extra fuel as may not be reutilized in the form of exhaust steam for adjoining buildings.

The following table shows the plant capacity in some typical buildings in New York City and the capacity held in reserve for spare purposes, which could be utilized for the supply of peak loads in the districts adjoining the buildings in question:

Plant	Capacity, Kw.	Max. Demand, Kw.	Spare Capacity, Kw.	Per Cent. Spare Capacity
Columbia Trust office	375	195	180	92
A. M. & Co. office and store	500	285	215	75
Bonwit-Teller store	875	600	275	46
103 Park Ave. office	225	111	114	102

It will be seen that the spare capacity is approximately 75 per cent. of the present maximum demand, so that there is already available a large amount of peak-load capacity which under suitable rate conditions could be utilized without the expenditure of a cent.

In private power plants the matter of fixed charges per kilowatt of maximum demand is not of as great importance as the matter of operating costs at light-load periods, and it is in this part of work that the public-utility company may counterbalance the advantage of the lower fixed charges of the private power plant. Load curves of some typical buildings show periods of from 8 to 12 hours when the load is only 5 to 10 per cent. of the maximum. This means comparatively high labor and fuel costs, except during the period of the year when low-pressure steam is required all night and every day for heating or other purposes. During seasons

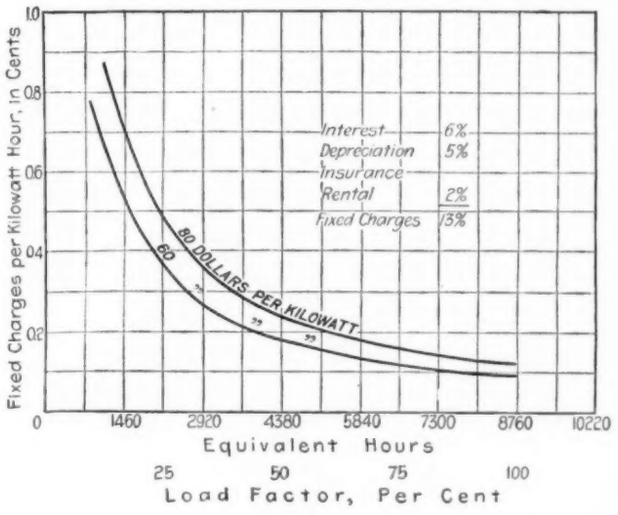


FIG. 9. FIXED CHARGES FOR DIFFERENT LOAD FACTORS, ISOLATED PLANTS

when low-pressure steam is not thus required, a kilowatt-hour may cost the private plant as much as 10c. and will usually be found to cost over 6c. exclusive of fixed charges. The period of this light load corresponds to the period of the light load of the public utility and the addition of this load to the public-utility load would be highly desirable, as it would involve substantially no increase in fixed charges and, as the light-load period of the public utility is the least efficient (all things being considered), the additional load at that period would cost less for production than at any other time, if it were properly considered as a marginal or increment cost.

It would seem, then, that a public-utility system using private power plants as steam substations would be the least expensive to build and operate. It would not be necessary for the public-utility company to purchase or lease the private plants, although this might prove desirable in many instances. All that is needed is a system of rates based on cost of service. This will lead to installation of plants where they are economically advisable and will do away with the artificial "protective" barriers interposed to prevent a proper economic solution of the problem.

A low rate for off-peak load will encourage private power-plant operators to shut these plants down at such periods and purchase from the public utility company, and these low rates for off-peak load might properly be coupled with agreements to buy power from the private plants at the period of peak demand at rates which would cover the cost to the private-plant operator of extra fuel and labor, if any, with a reasonable profit. Such a plan was proposed by the Longacre Electric Co. several years ago in New York City, but owing to troubles with franchise, it was not put into effect. It would seem to be the correct economic solution, and such engineering difficulties as might develop would be readily overcome.

Temperature-Measuring Devices

In a paper, "Pyrometers—Past, Present and Future," read before the Steel Treating Research Club, of Detroit, Mich., Richard P. Brown, president of the Brown Instrument Co., outlined the developments of the pyrometer. He said in part:

As far as we know, the ancients who baked excellent bricks and forged iron in their crude way, made use of a form of pyrometer used today with ever-diminishing success—the "Eye." Doubtless the Egyptian looked into a kiln and guessed the fire must be about right. He probably was not off more than a couple of hundred degrees, and very likely he guessed the temperature a great deal more accurately than some so-called pyrometers of later date. At a very early date attempts were made to measure temperatures by the expansion, contraction or fusing point of clay. Wedgewood, a potter in England, measured his kiln temperatures in this manner in 1782. Today cones of clay are still in extensive use in brick and pottery plants. These cones are composed of various substances so mixed as to form a whole series with fusing or softening points about 20 deg. apart; for instance, with fusing points of 2100, 2120 and 2140 deg. F. respectively.

One of the early devices to measure temperatures was the mercurial thermometer. Mercury thermometers for temperatures up to 600 deg. F. have a vacuum above the mercury column. As mercury boils at 674 deg. F., thermometers graduated above this must have the mercury column under pressure to prevent boiling. A mercury thermometer graduated to 1000 deg. F. has 200 lb. pressure above the mercury column. This is about the limit, as the glass tubing will soften at temperatures of higher value, and the pressure necessary to prevent boiling becomes excessive.

After describing various other devices that had been developed and used with certain degrees of success for the measurement of temperatures, Mr. Brown added that for measuring temperatures above 1000 deg. F., the thermoelectric method has come to be by far the most largely used. A thermoelectric pyrometer consists of a thermocouple, a measuring device and the wires connecting them. If two pieces of wire of different material—for instance, one of copper and one of iron—are joined together and heated at the point of union, a small current of electricity will be generated. This is known as thermoelectricity, and the wires comprise a thermocouple. It is true that the current generated is very small. Wires of precious metals for high-temperature measurement, such as one wire of platinum and the other of 90 per cent. platinum and 10 per cent. rhodium, generate only 0.01 volt (10 millivolts) at a temperature of 2000 deg. F. Wires of base metals, such as iron, copper and nickel, for measuring moderate temperatures, generate several times the voltage of a platinum thermocouple, or about 50 millivolts at 2000 deg. F. Experience seems to show that for measuring temperatures up to 200 deg. F. a thermocouple of bismuth and antimony is best.

Thermocouples of base metal are manufactured of diameters running from 0.01 in. up to 0.25 in. Platinum-rhodium thermocouples usually are furnished with wire of a diameter of 0.02 in. However, they have been made with wire less than 0.01 in. in diameter.

There are two distinct methods of measuring the voltage produced by a thermocouple, namely, the millivoltmeter method and the potentiometer method. The millivoltmeter directly reads the temperature across the scale and is calibrated in actual degrees. It indicates the temperature from zero to a maximum scale range; it relies entirely on the voltage of the thermocouple for its operation, no outside source of current being necessary.

The advantage of the potentiometer method of measuring temperatures is in its extreme precision, and it is independent of resistance changes throughout the thermocouple circuit. It has the disadvantage as compared with the millivoltmeter method that it is not direct reading and that some outside source of current, a dry cell for example, is necessary as a source of current to oppose the thermocouple, and this dry cell must be replaced from time to time.

USE OF RADIATION TYPE OF PYROMETERS

The radiation type of pyrometer is used to measure temperatures from 2800 deg. F. up. In this type, instead of placing the thermocouple in the furnace where the temperature would be so high as to destroy it, it is placed in the back of a tube in front of a mirror. The rays of heat from the furnace enter the tube and strike the mirror and are brought to a focus on a thermocouple junction which attains a temperature of only 200 or 300 deg. F. It is not recommended for service where a thermoelectric pyrometer with base metals or platinum thermocouples can be used.

It is very essential, if accurate results are to be secured from pyrometers, that they be restandardized at frequent intervals. If a thermocouple is installed in a furnace and allowed to run for six months without retesting, sooner or later it will fail and the user will find that the temperature measurements are away off. The frequency of standardizing depends on the precision necessary in the work and the equipment available. Some plants make a point of checking their thermocouples once a week; if this is impossible it should be done at least once a month.

This checking can be very satisfactorily done by maintaining a standard platinum thermocouple used for checking secondary standards of base metals. An electric furnace should be used not less than 10 in. deep so that a base-metal thermocouple can project at least 6 or 8 in. inside the furnace. The base-metal thermocouple can be tied to the standard thermocouple with asbestos strings, the junctions of the two thermocouples almost touching each other. The thermocouples should never be tested in their protecting pipe. A base-metal thermocouple can never be tested in a furnace with an insertion of less than 6 in., for the reason that the cross-section of the thermocouple wires is large, and the outer end of the thermocouple wires in the cold air conducts the cold along the wires into the furnace and will reduce the indication at the thermocouple junction on this account. The temperature of an electric furnace should be maintained constant for at least 15 minutes before a reading is taken, and tests should preferably be made at the working temperature of the thermocouple.

If the thermocouple under test reads low and it has no adjustable resistance, it will have to be "junked." If it is furnished with a resistance for adjustment purposes, this adjustment can be easily made with a soldering iron.

METHODS OF CHECKING THERMOCOUPLES

The freezing point of pure salt affords an excellent method for testing thermocouples or of the complete pyrometer, consisting of the thermocouple, leads and instrument. Insert a thermocouple in a small crucible containing pure salt (ordinary table salt is satisfactory) and heat to about 1600 deg. F. Remove the crucible from the heat and allow it to cool off. At the freezing point of the salt, which will be indicated by the temperature remaining reasonably constant for four or five minutes, the pyrometer will read 800 deg. C., or 1474 deg. F.

The melting point of a number of different metals is quite satisfactory for the checking purpose. The metals most generally used for this purpose and their melting points are as follows: Tin, 450 deg. F.; zinc, 787 deg. F.; silver, 1761 deg. F.; and gold, 1945 deg. F.

The Bureau of Standards at Washington is in a good position to test pyrometers and thermocouples for manufacturers in this country, and it is a good plan to have a standard platinum or base-metal thermocouple tested there. They can furnish the millivolt values for the thermocouples, and this can be retained as a primary standard to test the secondary thermocouple. The cost of such a test is usually about $10, and the expense is well warranted.

It would appear that the greatest development work in temperature-measuring instruments will be done with the perfection of optical pyrometers, resistance thermometers and thermoelectric pyrometers. There is a field for a high-grade optical pyrometer that can be used by any number of operators who will all secure the same results from the

instrument. However, the greatest future in pyrometry would seem to be along the line of automatic temperature control. Instruments have been developed for automatically maintaining the temperature constant within 10 deg. F.

New Jersey N.A.S.E. Holds State Convention

On Saturday and Sunday, June 2 and 3, the New Jersey State Association of the National Association of Stationary Engineers held its annual convention at Odd Fellows Hall, Hoboken, New Jersey.

Heretofore the New Jersey State conventions have been of an elaborate kind. The exhibits in connection with these conventions in New Jersey for the past several years have been, perhaps, the largest of all state conventions of the N. A. S. E. throughout the country. This of course made it impossible for most of the associations making up the state organization to entertain the convention, because of lack of hotels, but particularly because of the impossibility of housing the exhibits in any of the halls in the smaller towns. It was to get away from this condition and make it possible for the associations in smaller cities to entertain the convention that at Paterson last year it was voted to hold the convention at Hoboken in 1917.

The hall in Hoboken was admirably suited for the purpose. All meetings, exhibits, entertainments and refreshments were to be had under one roof. Instead of the usual booths and the exhibits of heavy machinery, tables and chairs were provided. There were 28 exhibitors at the convention.

Approximately 90 delegates attended. Thomas A. Brown, of Newark, president of the association, occupied the chair. The License Committee reported that chiefly through its efforts the Board of Examining Engineers in the State Engineers' and Firemen's License Bureau had been granted an increase in salary by the legislature, and that penalties for violation of the license law had been provided in amendments to the law. Examiner Joseph Scott of the State License Bureau, stated that the engineers could be assured that all would be done that cooperation could possibly accomplish to keep prosecutions for violation of the law down to a minimum, but that the Department of Labor, responsible for the application of the law, would prosecute. The State Educational Committee reported excellent work done by all of the associations, and made the following recommendations, which were concurred in by the convention: First, that all associations notify the committee of their plans, so that the educational work of the entire state might be most systematically organized; second, that a suitable trophy be purchased by the committee, to be put up as a prize for debates on engineering subjects by debaters from the associations of the state (the details of this recommendation are to be worked out by the committee); third, that appropriate measures be taken to better acquaint owners and managers with the purposes of the National Association of Stationary Engineers. The committee laid especial emphasis on the importance of this last recommendation, and in adopting it the Committee on Analysis and Distribution recommended that a publicity committee be appointed to work in conjunction with the State Educational Committee on this matter. An appropriation of $100 was voted to the Educational Committee. State Deputy Mrs. C. McCoy briefly addressed the convention, stating that the auxiliary now had 52 associations, over 900 members and 18 pensioners. During the year, $105 had been turned over to the national organization by the New Jersey auxiliary. Among other visitors to the convention were Walter H. Damon, past national president of the National Association of Stationary Engineers; Joseph H. Carney, past national president and ex-chairman of the National Board of Trustees; and the first national president of the N. A. S. E., Henry D. Cozens, of Newark, N. J.

Saturday evening the convention listened to Mr. Damon, Mr. Carney and Charles H. Bromley, as speakers, and to the following entertainers: Bert Self, of the Peerless Rubber Manufacturing Co.; Joe McKenna and Billy Murray, of Jenkins Bros., and Monroe Silver, and Jack Armour, of "Power." The smoker was under the direction of Frank Martin, of Jenkins Bros.

On motion of William J. Reynolds, past national president and member of the local committee, the association decided to purchase Liberty Bonds. The convention next year will go to Perth Amboy. Sunday afternoon, Stevens Institute and the W. & A. Fletcher Co., shipbuilders, where many turbines were to be seen in course of construction, were visited by the convention.

The following officers were elected: John J. Reddy, of Jersey City No. 1 Association, president; James F. Heath, of Elizabeth No. 14, vice president; H. Secor, of the Phillipsburg Association, secretary; William Kraus, of Passaic, treasurer; H. W. Vail, of Plainfield, conductor; H. R. Dallery, Bayonne, doorkeeper. President Thomas A. Brown was elected state deputy.

The convention committee was highly commended by those in attendance for the unusual success of the convention.

Government Boiler-Plate Rules Amended

On account of the contention of manufacturers of boiler plate that the requirements of the rules of the Board of Supervising Inspectors, United States Steamboat-Inspection Service, governing the manufacture of steel boiler plate are stringent, resulting in a cost of from 5 to 6c. a pound for steel boiler plate manufactured under the rules of the Steamboat-Inspection Service, in excess of that subject to the rules of Lloyds Bureau, the executive committee of the Board of Supervising Inspectors, at a meeting held from May 16-19, 1917, adopted the following rule for physical qualities of steel plates:

The tensile strength determined by the tests shall be not less than 58,000 lb. per sq.in. of section, nor more than 73,000 lb. per sq.in. of section, and the elongation measured in a gage length of 8 in. shall be not less than 20 per cent.

Before amendment, the rule read:

When the tensile strength determined by the test is less than 63,000 lb., the minimum elongation shall be 25 per cent. for plates $\frac{3}{4}$ in. and under in thickness, and 22 per cent. for plates over $\frac{3}{4}$ in. thick.

The rules reading "All holes for tubes shall be drilled and no part punched" and "All holes for stays shall be drilled and no part punched" were struck out, and the following new rule was adopted:

Centers or guide holes not to exceed 75 per cent. of the diameter of the full size finished hole for tubes and stays may be punched. The remainder shall be cleanly cut, drilled, or reamed to full size.

These amendments received the approval of the Secretary of Commerce on May 19, 1917, under the provisions of section 4405, Revised Statutes.

The Steamboat-Inspection Service has issued a circular letter dated May 22, 1917, which contains these amendments in full. The circular letter will be issued to manufacturers of boiler plate, boiler manufacturers and to all persons on mailing lists to receive the general rules and regulations of the Board of Supervising Inspectors. Copies of the circular letter may be obtained on application to any board of local inspectors, Steamboat-Inspection Service.

PERSONALS

N. L. Snow, sales manager of the Terry Steam Turbine Co., of Hartford, Conn., has been elected vice president of that company.

Henry F. Russell, formerly with the Lumen Bearing Co., is now sales manager of the grey-iron foundry department of Farrar & Trefts, Inc., Buffalo, N. Y.

D. H. Thomson has been elected president and treasurer of the Terry Steam Turbine Co., of Hartford, Conn., filling the vacancy caused by the death of the late James Terry.

Huntley Abbott, vice president and chief engineer of MacArthur Concrete Pile and Foundation Co., has resigned from that company to accept a position with the Bartlett Hayward Co., of Baltimore, Md.

Francis C. Shenehon, for the past eight years dean of the College of Engineering of the University of Minnesota and head professor of civil engineering, has opened offices in the New Metropolitan Bank Building, Minneapolis, and will give his entire attention to his practice as a consulting hydraulic engineer. Mr. Shenehon was engineering expert for the United States Government in the extensive litigation in connection with the Chicago Sanitary Canal, etc., and during the past year has been engineering expert for the Marseilles Land and Water Power Co.

Boiler Today, Smokestack Tomorrow—Perhaps the longest steam boilers ever constructed in this or any other country were located in a sawmill at St. John, New Brunswick, being 36 in. diameter and 90 ft. long. They were plain cylindrical boilers without flues, constructed of fifteen courses, one plate to the course, the longitudinal joints being of the double-riveted lap-seam type and set in a battery of six, the distance between shells being 12 in. The fuel used was sawdust. These boilers, after having been in service for a number of years, are now being dismantled, and after the heads are removed they will be used as a smokestack.—"Monthly Bulletin," Fidelity and Casualty Co.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	June 9, 1917	One Year Ago	June 9, 1917	One Year Ago
Buckwheat	.....	$2.05—3.20	$6.00—6.75	$3.25—3.50
Rice	.....	2.50—2.65	5.20—5.85	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	.....	2.20—2.35	4.90—5.00*	2.35—2.60

*No prices quoted.

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	June 9, 1917	One Year Ago	June 9, 1917	One Year Ago
Clearfields	$4.75—5.50	$1.00—1.55	$8.75—10.00	$4.25—500
Cambrias and Somersets	5.00—5.75	1.30—1.75	9.25—10.00	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $7.50—8, as compared with $2.75—2.85 a year ago; on cars Boston price is $11.25—11.75.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	June 9, 1917	One Year Ago	June 9, 1917	One Year Ago
Buckwheat	$4.00—4.15	$2.75	$5.00—5.25	$2.25—2.75
Rice	3.40—4.05	2.25	4.00—4.25	2.20—2.25
Barley	2.90—3.10	1.75	3.00—3.25	1.70—1.75

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$6.75—7.25	$6.75—7.25	$4.75—5.50
South Forks	7.00—7.25	.....	5.00—5.50
Nanty Glo	7.00—7.25	.....	5.00—5.50
Somerset	6.75—7.00	6.75—7.00	4.75—5.25
Quemahoning	7.00—7.25	7.00—7.25	5.00—5.50

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	June 9, 1917	One Year Ago	June 9, 1917	One Year Ago
Buckwheat	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	....
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	....

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	June 9, 1917	One Year Ago
Slack	$4.75—5.00	$1.65—1.90
Mine-run	4.75—5.00	1.75—2.00
¾-in.	4.75—5.00	1.85—2.10

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Spring-field	Clinton and Sullivan Counties
Steam lump	$3.00—3.75	$3.00—3.75	$5.75—6.25	$3.00—3.50	$3.00—3.25
Lump	3.25—3.75	3.25—3.75	5.75—6.25	3.25—3.50	3.25—3.75
Egg	3.25—3.75	3.25—3.75	.....	3.25—3.50	3.25—3.75
Nut	3.25—3.75	3.25—3.75	.....	3.25—3.50	3.25—3.75
No. 1 nut	3.25—3.75	3.25—3.75	.....	3.25—3.50	3.25—3.75
No. 2 nut	3.25—3.75	3.25—3.75	.....	3.25—3.50	.....
No. 3 nut	3.00—3.75	3.00—3.75	.....	3.00—3.25	.....
No. 1 washed	3.25—3.75	.....	.....	.....	.....
No. 2 washed	3.25—3.75	.....	.....	.....	.....
Mine-run	3.00—3.75	2.75—3.50	5.00—6.00	2.75—3.25	2.75—3.50
Screenings	3.00—3.75	2.75—3.50	.....	2.75—3.25	2.75—3.50

Hocking lump, $4.25–4.75; splint lump, $4.25–4.75.

St. Louis—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	June 9, 1917	One Year Ago	June 9, 1917	One Year Ago	June 9, 1917	One Year Ago
6-in. lump	$3.50	$1.45	$2.25	$1.25	$2.00	$1.00
2-in. lump	3.50	1.45	2.25	1.15	2.00	.85
Steam egg	3.50	1.45	2.25	1.15	1.75	.85
Mine-run	3.25	1.25	2.25	1.10	1.75	.80
No. 1 nut	3.50	1.45	2.25	1.25	2.00	1.00
2-in. screen	2.75	1.00	2.25	.85	1.75	.80
No. 5 washed	2.50	.80	2.25	.80	1.75	.80

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.75—4.25	Carbon Hill	$3.25—3.50
Big Seam	3.00—3.50	Cahaba	3.75—4.25
Black Creek	3.75—4.25		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Calif., Porterville—The Mount Whiting Power Co. is having surveys made for a new power plant. H. W. Heard, Engr. Power Station.

Ga., Milan—The Georgia & Southern Utilities Co. plans to extend its transmission line into Milan.

Ill., Gillespie—The Southern Illinois Light and Power Co. will erect an addition to its electric plant and will install new machinery. J. J. Frey, Hillsboro, Mgr.

Ill., Gobson City—City is considering plans for an electric-light plant. Estimated cost $22,000.

Iowa, Centerville—The Centerville Light and Traction Co. has purchased a number of small central station companies, and will erect a 13,200-volt transmission line to connect the plant with the main power station. F. S. Payne, Pres. and Mgr.

Iowa, Davenport—The Tri-City Railway and Light Co. plans to improve its system, including rebuilding electric transmission lines, installing a 20,000-kw. turbine, new equipment, etc. Estimated cost $400,000. H. C. Blackwell, Gen. Mgr.

Iowa, Morehead—City voted in favor of issuing bonds to install an electric-lighting system.

Iowa, Mount Vernon—The Wapsi Power and Light Co. is having plans prepared for extending its transmission lines out of West Branch, about 8 or 9 mi., touching the villages of Centerdale and Springdale. A. Meakin, Mount Vernon, Ch. Engr.

Kan., Haddam—The Concordia Light and Power Co. will extend its transmission lines to Cuba, Aganda and Washington.

Kan., Long Island—City will soon receive bids for an electric-lighting system, including a 13,200-volt 3-phase electric transmission line, about 9 miles long, to connect with the electric plant at Phillipsburg; a pole type transformer substation, equipped with three 10-kw. transformers and multiphase meter; street-lighting system, consisting of 22 series lamps with transformer, meter and time clock, lamps to be suspended by cable over center of the streets; distributing system, to include three 7½-kw., 2300-220-110-volt transformers and one 2-kw. transformer, also wiring about 75 buildings. Meters will be purchased by the city. C. F. Sturtevant, Holdredge, Neb., Engr. in charge.

Kan., McFarland—The Alma Light Co. has been granted a franchise by the City Council to install an electric-light system here.

Ky., Hardinsburg—The Hardinsburg Electric Light Co., recently organized, will construct an electric plant. Alfred Taylor is reported interested.

Mass., Springfield—The Springfield Street Railway Co. has been granted a permit to erect a new substation. Estimated cost $30,000. H. M. Flanders, Mutual Bldg., Gen. Mgr.

Miss., Fernwood—The McComb & Magnolia Light and Railway Co., McComb, will construct a power plant here. S. M. Jones, Laurel, Pres.

N. J., Newark—The Public Service Electric Co., Terminal Bldg., will construct an addition to its point-no-point generating station. Estimated cost $365,000. N. A. Carle, Ch. Engr.

N. J., Trenton—The Empire Tire and Rubber Corp. will construct a 1-story addition to its power house at its plant on North Clinton Ave. Estimated cost $10,000.

N. Y., Albany—The Albany Southern R.R. is having plans prepared by the J. G. White Engineering Corp., 43 Exchange Place, New York City, for a hydro-electric power plant in the Catskill Mountains. Estimated cost $3,000,000. J. E. Hewes, 100 Broadway, Albany, Gen. Mgr.

Ohio, Cincinnati—The Charles Boldt Co., Eggleston Ave., will construct a power plant in connection with its paper mill, now being constructed.

Ohio, Cleveland—Bd. of Education is having plans prepared by W. R. McCormack, Arch., 779 East 89th St., for a power house at the Norwood School. Estimated cost, $50,000.

Ohio, Marion—The Columbus, Delaware & Marion Railway Co. will construct additions to its power plant here. J. H. Lahrmer, 100 West Gay St., Supt.

Ohio, Youngstown—The Brier Hill Steel Co., Stambaugh St., will install several large motor-generating sets of about 1500 hp. each for the generation of all direct current required for electrifying its proposed new plant, which is to be operated entirely by electricity. Energy will be supplied by the Mahoning & Shenango Railway and Light Co.

Okla., Collinsville—City plans to improve the electric-lighting plant and will install additional machinery. Estimated cost $14,000.

Okla., Okarche—City Council plans to install an electric-lighting plant.

Ont., Campbellford—Town Council has passed a bylaw appropriating $19,000 to extend and improve its electric-lighting and power system.

Ore., Astoria—The Port of Astoria Comn. will construct its own power plant for the operation of the machinery at the port elevator and coal bunkers.

Penn., Lancaster—The Conestoga Traction Co., Lampeter St., will extend and improve its plant and system.

Penn., Philadelphia—A power plant will be constructed at the Byberry Hospital by the Dept. of Charities. Esimated cost $76,900.

S. D., Bonesteel—City is having plans prepared by Bruce & Standeven, Engrs., Bee Bldg., Omaha, for an electric-light plant.

Wash., Seattle—The Puget Sound Traction, Light and Power Co., 7th and Olive St., will construct a substation at First South and Spokane Sts., including a 500-kw. motor generator. Estimated cost, $12,000.

Wis., Birnamwood—The Charles W. Fish Lumber Co. will soon receive bids for a 35 x 115-ft. power plant and steam generating equipment.